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SOIL ANALYSIS: An Aid In The Fertilization Of Vegetable Crops

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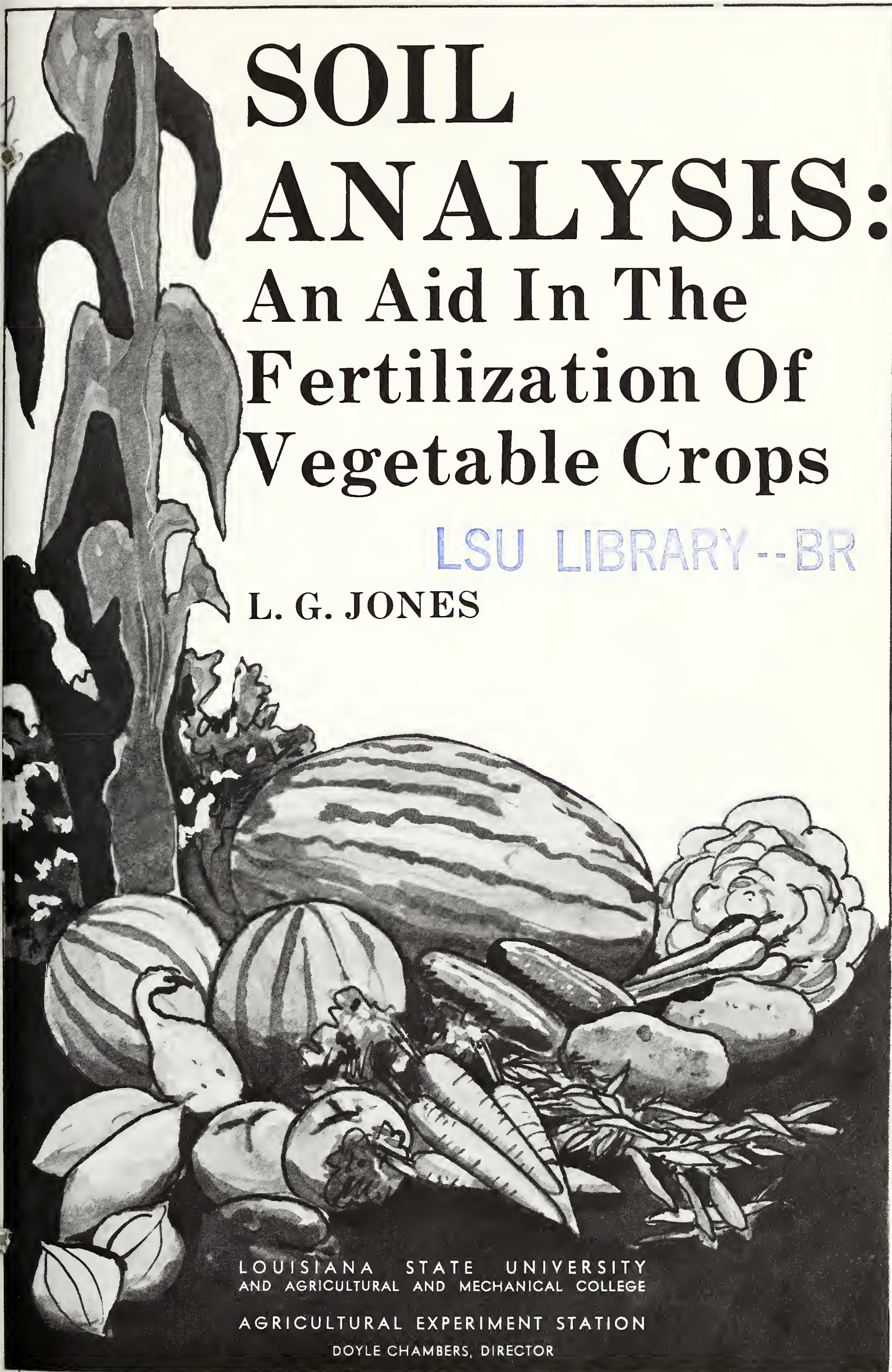

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Soil Analysis: An Aid in the Fertilization Of Vegetable Crops

L. G. Jones[1]

INTRODUCTION

Many different kinds of soil in Louisiana are used for the production of vegetable crops. These soils vary widely in geological age, parental material, means of deposition, reaction, total and soluble plant nutrient content, native vegetation, and many other aspects influencing their suitability for the growth of various vegetable crops. Many of these soils have been studied in great detail and described to a marked extent in terms of characteristics pertinent to crop production. The morphology and relief relationships of representative soils from the seven general soil areas in Louisiana have been described by Lytle (*4*[2]). The easily extractable nutrient levels of many of these soils have been determined by Brupbacher et al. (*2*) using widely accepted laboratory methods of analysis (*3*). The extractable levels of the individual nutrients calcium, magnesium, phosphorus, and potassium present in these soils have been discussed by Peevy (*6, 7, 8, 9*).

Any vegetable crop plant will show a tendency to absorb and make use of a plant nutrient in proportion to the amount of that nutrient that is easily extractable from the soil, whether the nutrient is present as soluble salt in the soil solution or held relatively loosely by the soil colloidal material. This tendency will vary somewhat with individual nutrients. The amount taken up may also be affected by the presence of complementary ions, antagonistic ions, and numerous soil and environmental conditions considered inappropriate for this discussion. However, the total uptake of a given nutrient is related in a general way to the amount of that nutrient present in the soil in an "available" form. Thus, a vegetable crop grown on a soil that is relatively high in availability of a particular plant nutrient will not require the application of a large amount of that nutrient as fertilizer in order to make good growth and high yield. Conversely, a plant grown on a soil relatively low in supplying-capacity of a given nutrient must receive a liberal application of that nutrient in the form of fertilizer before satisfactory growth and yield are obtained. The problem, then, defines itself as determining in quantitative terms the amount of fertilizer nutrients that must be applied to a given soil at any level of those nutrients already in the soil in order to produce a good crop. This method of correlating the response by crop plants to fertilizer applications with the level of extractable nutrients in the soil has become a major approach to the solution of many problems in soil fertility. Experimental work done from this approach will provide information that will allow an experienced worker to predict rather closely the kind and amount of fertilizer that should be applied to a given soil at a given level of fertility for a particular crop to perform satisfactorily. In this way, the nutrient-supplying capacity of the soil in question and that of the fertilizer used are considered and added together to provide the total nutrient requirements of the crop being grown. This method of determining fertilizer requirements is more specific than that of simply conducting field response tests to fertilizer applications without taking into account the amount of each plant nutrient already present and available in the soil before fertilizer applications are made.

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[1] Professor of Horticulture, Horticulture Department, Louisiana Agricultural Experiment Station.

[2] Italic numbers in parentheses refer to items in References, page 24.

The Soil Testing Laboratory at Louisiana State University has been in operation for a number of years, and many soil samples representative of the soils in the seven major soil areas have been analyzed for easily extractable nutrient content. In this way, a backlog of information has been compiled relative to the "available nutrient" levels of each of these soils and as such provides a scale by which the fertility level of any given soil in the state may be rated. Accordingly, it is now known at which levels of extractable nutrients these soils are considered low, medium, or high. If most of the soils in a given soil area were medium (or average), then the general fertilizer recommendations published earlier in Circular No. 84 (*12*) would be sufficiently accurate and specific enough for good crop production. But it is a fact that many of the soils in a given area are not medium or average in extractable nutrient levels for various reasons. Thus, it becomes necessary to determine, through soil analysis procedures, whether a particular soil is lower or higher than average and to relate this information to crop response data in order to make some adjustment in the general fertilizer recommendations mentioned above before a farmer can produce maximum yield. This type of information has been provided recently by Peevy (*5*) for field crops, and such information is also badly needed by Cooperative Extension personnel and others giving advice to farmers relative to vegetable crop production. Thus, an attempt is made herein to furnish a soil fertility scale for the different soils in the state on which vegetable crops are grown. Some of the soils have been grouped, with some reservation and reluctance by the writer, for reasons of practicality, since they are somewhat similar in nutrient-supplying capacity. Some of the vegetable crops have also been grouped in view of their similar nutrient requirements and capacities to absorb nutrients from the soil.

PRESENTATION

A soils map[3] showing the location of the seven general soil areas in Louisiana is presented on Pages 12-13. The alluvial soils, having been stream deposited, show a wide range in soil texture as well as organic matter content; thus, the total exchange capacity of these soils, considered collectively, also shows a wide variation. In view of this situation, it was felt advisable to separate these soils into two categories for this presentation: Light Alluvial Soils with a relatively low exchange capacity, and Heavier Alluvial Soils with higher exchange capacity. The next grouping of soils for this presentation includes the Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi River Terrace areas. Here again, there exists some range in texture, organic matter, and consequently total exchange capacity, but for the sake of generalization it was deemed justifiable, although somewhat undesirable, to include all of these soils in one category for purposes of making fertilizer recommendations. The third group of soils is designated only as the Coastal Plain (Hill) area. Within this group there is considerably less variation in texture and organic matter (exchange capacity) in the topsoil than in that of the other two groups given above; therefore, in a general consideration it did not seem feasible to separate any of the soils in the Coastal Plain group.

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[3] Reprinted with permission of the author, S. A. Lytle, from Louisiana Agricultural Experiment Station Bulletin No. 631, November 1968.

The data on suggestions for fertilization of the vegetable crops presented in Tables 1-15 are based on information from many sources. In addition to that from the LSU Soil Testing Laboratory already mentioned, a great number of field experiments on vegetable nutrition have been carried out in the state over a period of approximately 40 years by research personnel at the Main Experiment Station at Baton Rouge and at the various Branch Stations involved in horticultural work. The results of some of this work have been published, but many of them remain unpublished; however, they were available to the writer and were studied carefully by him prior to beginning this presentation. In addition to local sources of information, certain textbooks and periodicals were used also as reference sources (*1, 10, 12*).

The information presented in Tables 1-15 in tabular form pertain to phosphorus and potassium only, and the letters VL, L, M, and H mean Very Low, Low, Medium, and High levels in the soil, respectively. Additional information on nitrogen applications is shown in narrative form below each subtable. These data may be used to determine the proper amount of each element to be applied as fertilizer per acre, whether applied as materials or grades. As an example, consider cabbage to be grown on Light Alluvial Soil (Table 1). If this soil analyzed 70 ppm of extractable phosphorus (Low) and 90 ppm of extractable potassium (Low), then an application of 90 pounds per acre of phosphate (P_2O_5) and 90 pounds per acre of potash (K_2O) would be suggested. This, in combination with the 45 pounds of nitrogen suggested as a preplanting application, would conform to a convenient fertilizer ratio of 1-2-2, which is widely available in the state. The additional 20-30 pounds of nitrogen to be applied as side-dressing during the growing season would consist of a material only, of course. This type of interpretation will apply to the information in all tables presented herein. Another example may be given (Table 1). If cabbage is to be grown on Light Alluvial Soil analyzing 100 ppm of extractable phosphorus (Low-Medium) and 120 ppm of extractable potassium (Low-Medium), an application of 75-80 pounds of phosphate (P_2O_5) and 75-80 pounds of potash (K_2O) would appear appropriate. This, together with the 40 pounds of nitrogen to be applied before planting, would again fit conveniently into a 1-2-2 ratio in any grade that would supply the plant nutrients recommended. A third example may be in order (Table 1). Again, using the same crop on the same soil analyzing 70 ppm of extractable phosphorus (Low) and 150 ppm of extractable potassium

(Medium), an application of 90 pounds of phosphate (P_2O_5) and 60 pounds of potash (K_2O) would be suggested. In this case, if only 30 pounds of nitrogen are applied before planting, with the remainder (30-40 pounds) to be applied as side-dressing later, then a fertilizer ratio of 1-3-2 in any appropriate grade may be used. Finally, a fourth example might be helpful (Table 1). With the same crop and soil and an analysis of 130 ppm of phosphorus (Medium) and 90 ppm of potassium (Low), an application of 60 pounds of phosphate (P_2O_5) and 90 pounds of potassium would be indicated. Again, 30 pounds of nitrogen may be applied before planting and the remaining 30-40 pounds applied later as side-dressing. With this provision, the preplanting fertilizer would fit into a 1-2-3 ratio in any desired grade.

The suggested levels of calcium and magnesium in the soil also vary with crop and soil type, as does the soil reaction (pH). If the soil analysis reveals that the extractable level of either of these nutrients is too low, or the pH is too low, appropriate measures should be taken well in advance of fertilization of the crop to be planted (preferably several months). The proper amounts of these nutrients may be furnished by the application of finely ground agricultural limestone (primarily calcium carbonate) or dolomitic limestone (approximately 60 percent calcium carbonate and 40 percent magnesium carbonate). The choice of limestone to be used will be determined by the levels of extractable calcium and magnesium already present in the soil. The rate of limestone application will be determined by these factors also, as well as by the current pH of the soil and the point to which it is desirable to raise the pH.

In a few cases it may be desirable to raise the level of extractable calcium or magnesium in the soil without altering the soil reaction. If so, a neutral salt of either of these nutrients may be used for this purpose. Information on the type of salt and the rate of application is available from the LSU Soil Testing Laboratory or from the Horticulture Department.

Also, in rare cases it may be desirable to increase the acidity (lower the pH) of the soil without greatly changing the calcium or magnesium level. Usually, some form of sulphur that will be transformed into sulphuric acid in the soil is used for this purpose. However, the proper handling of this amendment is a difficult task, and anyone contemplating such application is strongly urged to contact the LSU Soil Testing Laboratory for technical aid in this operation.

TABLE 1. CABBAGE, CAULIFLOWER, BROCCOLI, BRUSSELS SPROUTS, LETTUCE

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*Apply 40-50 pounds of N per acre before planting and a side-dressing of 20-30 pounds at 3-4 weeks after planting. The extractable calcium[2] level should be 1,000-1,500 ppm, with magnesium[2] at 150-300 ppm, and a soil pH of 5.8-6.8.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*Apply 30-40 pounds of N per acre before planting and side-dressing of 20-30 pounds at 3-4 weeks after planting. Calcium[2] should be extractable at 1,500-3,000 ppm, with magnesium[2] at 300-500 ppm, and a soil pH of 5.8-6.8.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*These soils should receive an application of about 50 pounds of nitrogen per acre before planting and a side-dressing of 25-30 pounds of N at 3-4 weeks after planting. The extractable calcium[2] level should be 500-1,000 ppm, with a magnesium[2] level of 125-200 ppm, and a soil pH of 5.6-6.4.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*These crops grown on Hill soils usually require about 60 pounds of nitrogen per acre before planting plus a side-dressing of 25-30 pounds of N at 3-4 weeks after planting. Calcium[2] should be extractable at 400-800 ppm and magnesium[2] at 100-200 ppm, with a soil pH of 5.6-6.4.

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[1] Extractable with 0.1 N HCl + 0.03 NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 2. CUCUMBERS, SQUASH

Light Alluvial Soils (loamy sand, sandy loam, fine sandy loam, very fine sandy loam)*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 0-60 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 0-30 pounds of this nitrogen before planting and 0-15 pounds as side-dressing when the vines begin to run. In addition, apply 0-15 pounds of N about the middle of the harvest season. These soils usually contain enough extractable calcium and magnesium for these crops. The pH should be 5.5-6.5

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Use only the lighter-textured soils for cucumbers and squash. Apply 30-40 pounds of nitrogen per acre before planting, plus 20-30 pounds of N as side-dressing when the vines first begin to run. An additional application of 15-20 pounds of N during the middle of the harvest season may be necessary, especially if a high-yielding variety is used. The extractable calcium[2] and magnesium[2] levels should be 400-600 ppm and 125-200 ppm respectively, with a soil pH of 5.4-6.2.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 40-50 pounds of nitrogen per acre before planting, plus 25-30 pounds of N when the vines first begin to run. An additional side-dressing of N at a rate of 20-30 pounds per acre may be applied after several weeks of harvest in order to prolong the harvest season, especially if a high-yielding variety is grown on a soil with a deep sandy top-soil. Calcium[2] and magnesium[2] should be extractable at 300-500 ppm and 100-150 ppm respectively, with a soil pH of 5.4-6.2.

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[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil-extractant ratio of 1:20.
[2] Extractable with a 0.1 N HCl at a soil:extractant ratio of 1:20.
NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 3. HOT PEPPER

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Apply 60-100 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 30-50 pounds of this nitrogen before planting and 15-25 pounds as side-dressing when the plants begin to set fruit and again 4-6 weeks later. Calcium[2] and magnesium[2] should be extractable at 1,000-1,500 ppm and 150-300 ppm respectively, with a soil pH of 5.6-6.6.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Apply 60-80 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 30-40 pounds of this nitrogen before planting and 15-20 pounds as side-dressing when the plants begin to set fruit and again 4-6 weeks later. Extractable calcium[2] should be 1,500-2,500 ppm, with magnesium[2] at 300-500 ppm, and a soil pH of 5.6-6.6.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Apply 30-40 pounds of nitrogen per acre before planting plus 2 side-dressings of N: the first at 20-25 pounds per acre when the plants begin to set fruit and the second at the same rate about 4-6 weeks after the first side-dressing application. Calcium[2] should be extractable at 500-1,000 ppm, and magnesium[2] at 150-200 ppm, with a soil pH of 5.6-6.2.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Apply 30-40 pounds of nitrogen per acre before planting plus 2 side-dressings of N: the first at 20-25 pounds per acre when fruit set has begun and the second at the same rate about 4-6 weeks after the first side-dressing application. The most productive extractable calcium[2] range is 400-800 ppm, with 125-200 ppm magnesium[2] and a soil pH of 5.6-6.2.

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[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 4. IRISH POTATOES

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Apply 60-80 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 40-50 pounds of this nitrogen before planting and the remaining 20-30 pounds as top-dressing at first plant emergence. In most cases, these soils contain sufficient extractable calcium and magnesium for potatoes. The soil pH should be 5.0-6.0, with the lower end of this range being preferable because of the danger of scab infection at the higher pH.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Apply 50-80 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 30-50 pounds of this nitrogen before planting and the remaining 20-30 pounds as top-dressing at first plant emergence. These soils usually contain sufficient extractable calcium and magnesium for potatoes. The soil pH should be 5.0-6.5, with the lower end of this range being preferable.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs/acre, (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Irish potatoes grown on these soils normally need 60-80 pounds of nitrogen per acre. About 40-50 pounds of N may be applied before planting and 25-30 pounds applied as a top-dressing at plant emergence. An extractable calcium[2] level of 400-800 ppm and a magnesium[2] level of 100-200 ppm should be sufficient. The soil pH should be within the range of 5.0-5.5.

Coastal Plain Upland (Hill) Soil*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	120	100	80	60

*Irish potatoes grown on these soils generally require 60-80 pounds of nitrogen per acre. About 40-50 pounds of N should be applied preplanting and the remainder of 25-30 pounds applied as top-dressing at plant emergence. Calcium[2] should be extractable at 400-600 ppm and magnesium[2] at 100-200 ppm, with a soil pH of 5.0-5.5.

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.
[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.
NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 5. OKRA

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	120	80	40	0

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	120	80	40	0

*If the soil contains 1.5-2.0 percent organic matter, no nitrogen application should be needed. If organic matter is 1.0-1.5 percent, then only a side-dressing of N should be applied at 15-20 pounds per acre after the first few pods have set on each plant. An additional 15-20 pounds of N may be applied at 4-6 weeks after the first application. On the soil with less than 1.0 percent organic matter, apply 15-20 pounds of N per acre before planting and side-dress the plants twice as described above. These soils usually contain sufficient extractable calcium and magnesium for okra. The soil pH should be 5.8-6.5.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	120	80	40	0

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-130 (L)	130-200 (M)	200 (H)
Apply, lbs./acre (K_2O)	120	80	40	0

*If the soil contains 2.0 percent or more of organic matter, no nitrogen application should be needed. On soils below 2.0 percent, then only 1 side-dressing of N may be needed at the rate of 15-20 pounds per acre when the first few pods have set on each plant. These soils generally contain sufficient extractable calcium and magnesium for okra. The soil pH should be 5.8-6.5

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*If the soil contains more than 1.5 percent organic matter, then only a side-dressing of 15-20 pounds of nitrogen per acre should be applied after a few pods have set on each plant. On soils with less than 1.5 percent organic matter, a preplanting application of 15-30 pounds of N should be used, followed by a side-dressing of 15-20 pounds of N after a few pods have set on each plant. An additional side-dressing of N may be needed, especially if it is desirable to prolong the harvest season. About 20 pounds of N per acre may be applied about 6 weeks after the first side-dressing application. The extractable calcium[2] level should be 400-800 ppm, and magnesium[2] should be extractable at 125-200 ppm. The optimum soil pH is 5.5-6.2.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	15 (VL)	15-60 (L)	60-120 (M)	120 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

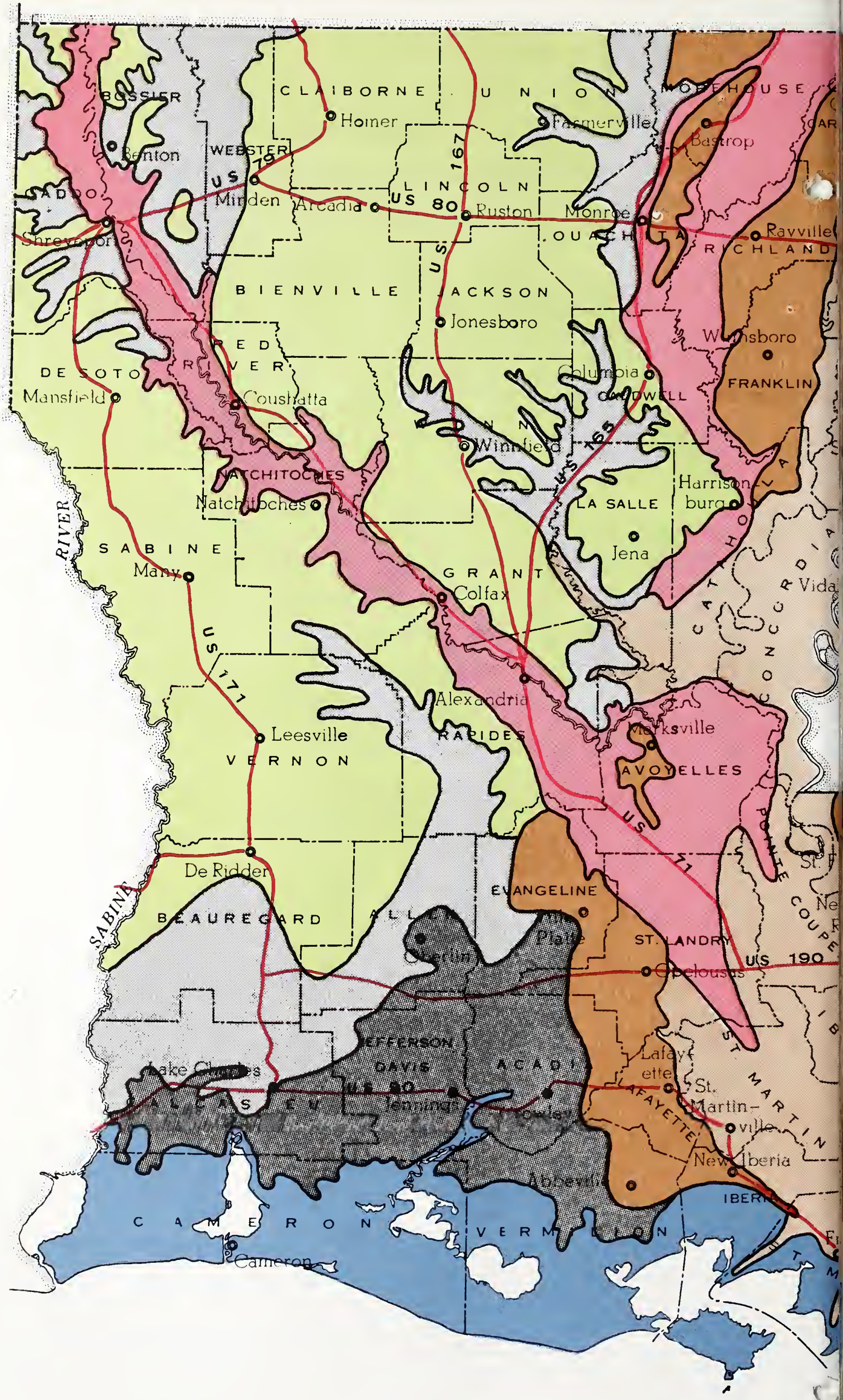
*On soils with less than 1.25 percent organic matter, a preplanting application of 20-30 pounds of nitrogen per acre should be used, followed by 2 side-dressings with N: the first at about 20 pounds per acre after a few pods have set on each plant and the second at the same rate after the plants have reached a height of about 4 feet. Extractable calcium[2] may range from 400-600 ppm, and magnesium[2] from 100-200 ppm, with soil pH 5.5-6.2.

---

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.


BOSSIER
Benton
CADDO
Shreveport
CLAIBORNE
Homer
WEBSTER
US 79
Minden
UNION
Farmerville
LINCOLN
Ruston
Arcadia
US 80
US 167
Monroe
OUACHITA
MOREHOUSE
Bastrop
Rayville
RICHLAND
BIENVILLE
JACKSON
Jonesboro
RED RIVER
Coushatta
DE SOTO
Mansfield
Winnsboro
FRANKLIN
Columbia
CALDWELL
WINN
Winnfield
US 165
NATCHITOCHES
Natchitoches
LA SALLE
Jena
Harrisonburg
CATAHOULA
CONCORDIA
Vidalia
SABINE
Many
RIVER
GRANT
Colfax
US 171
Alexandria
RAPIDES
Marksville
AVOYELLES
Leesville
VERNON
US 71
POINTE COUPEE
De Ridder
SABINE
BEAUREGARD
ALLEN
EVANGELINE
Ville Platte
Oberlin
ST. LANDRY
US 190
Opelousas
JEFFERSON DAVIS
ACADIA
Lafayette
LAFAYETTE
St. Martinville
ST. MARTIN
Lake Charles
CALCASIEU
US 90
Jennings
Crowley
New Iberia
IBERIA
Abbeville
CAMERON
Cameron
VERMILION

GENERAL SOIL AREAS IN LOUISIANA

🟩 GENTLY SLOPING TO HILLY COASTAL PLAIN—Shubuta, Ruston, Bowie, Lucy, Troup, Kirvin, Nacogdoches, Susquehanna, Ora, Sawyer, Boswell, etc., with Cahaba, Prentiss, Stough

🟧 LOESSIAL HILLS AND MISSISSIPPI TERRACES—Olivier, Loring, Memphis, Providence, Lexington, Calhoun, Jeanerette, etc., with Cascilla, Waverly, Collins

⬜ FLATWOODS AREAS—Caddo, Beauregard, Acadia, Frost, Calhoun, Zachary, Wrightsville, etc., with Bibb, Waverly

▨ COASTAL PRAIRIES—Crowley, Midland, with Beaumont, Bernard, Acadia

⬜ RECENT ALLUVIUM (MISSISSIPPI RIVER ALLUVIAL SOILS)—Sharkey, Mhoon, Commerce, Tunica, etc., with Cypremort, Dundee, Baldwin, Iberia, Jeanerette

🟪 RECENT ALLUVIUM (ALLUVIAL SOILS OF THE RED AND OUACHITA RIVERS)—Moreland, Norwood, Yahola, Perry, Portland, etc., with Gallion, Hebert, Pulaski

🟦 COASTAL MARSHLANDS—Marsh Peats, Mucks, Clays, and Harris, with Swamp Peats, Mucks, and Clays

Compiled by S. A. Lytle, Associate Professor, Department of Agronomy, Louisiana Agricultural Experiment Station, Baton Rouge, La. OCTOBER 1968

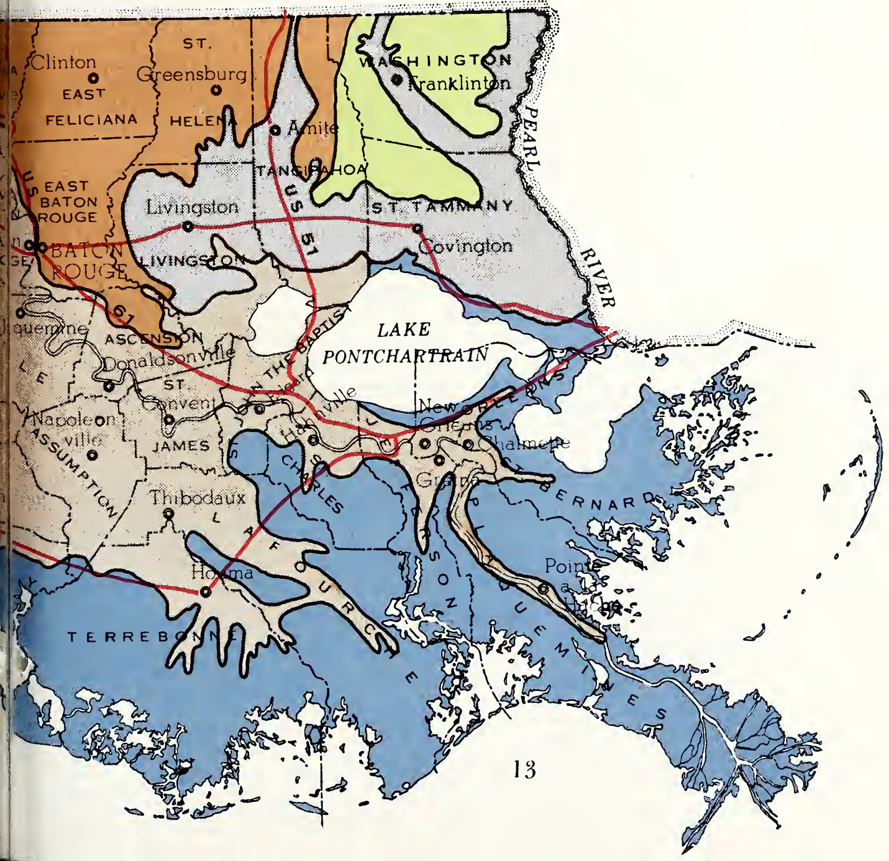


TABLE 6. ONIONS, SHALLOTS, GARLIC

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 25-30 pounds of N per acre before planting and a side-dresing of 20-30 pounds at 4-6 weeks after planting. Extractable calcium[2] should be 1,000-1,500 ppm, with magnesium[2] at 150-200 ppm, and a soil pH of 5.8-6.5.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 20-30 pounds of N per acre before planting and a side-dressing of 20-25 pounds at 4-6 weeks after planting. Calcium[2] should be extractable at 1,500-2,500 ppm, with magnesium[2] at 250-400 ppm, and a soil pH of 5.8-6.5.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply about 30 pounds of nitrogen per acre before planting and a side-dressing of 20-25 pounds of N at 3-4 weeks after planting. Calcium[2] and magnesium[2] should be extractable at 400-800 ppm and 125-200 ppm respectively, with a soil pH of 5.5-6.2.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 30-40 pounds of nitrogen per acre before planting, plus a side-dressing of 20-30 pounds of N at 3-4 weeks after planting. The optimum range for extractable calcium[2] and magnesium[2] is 400-600 ppm and 125-200 ppm respectively, with a soil pH of 5.5-6.2.

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 7. PEAS AND BEANS

Light Alluvial Soils (loamy sand, sandy loam, fine sandy loam, very fine sandy loam)*

Phosphorus				
Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	90	60	30	0

Potassium				
Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	90	60	30	0

*Apply 0-30 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Southern peas grown on these soils usually do not require any nitrogen applications and if the organic matter level exceeds 1.0 percent the plants may become excessively vegetative at the expense of fruit production. Calcium[2] should be extractable at 1,000-1,500 ppm, and magnesium[2] at 150-300 ppm, with soil pH 5.8-6.8.

Heavier Alluvial Soils (silt loam, silty clay loam)*

Phosphorus				
Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	90	60	30	0

Potassium				
Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	90	60	30	0

*Peas or beans grown on heavier alluvial soils usually do not require any nitrogen application. In fact, if the organic matter level exceeds 1.5 percent the plants may become excessively vegetative at the expense of fruit production. Southern peas should not be planted at all on these soils for this reason. The extractable calcium[2] level should be 1,500-3,000 ppm, with magnesium[2] at 300-500 ppm and a soil pH of 5.8-6.8.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus				
Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	80	60	40	20

Potassium				
Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	80	60	40	20

*These crops grown on these soils usually benefit from 15-30 pounds of N applied before planting. If the soil is unusually high in organic matter content (above 1.5 percent), then no nitrogen application should be needed. These crops grow best on soils well supplied with extractable calcium[2] (800-1,500 ppm) and magnesium[2] (150-200 ppm) and at a relatively high pH (5.6-6.4).

Coastal Plain Upland (Hill) Soils*

Phosphorus				
Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	80	60	40	20

Potassium				
Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	80	60	40	20

*These soils should receive 20-30 pounds of nitrogen per acre before beans or peas are planted. These crops require relatively high levels of extractable calcium[2] (600-1,000 ppm) and magnesium[2] (125-200 ppm) and soil pH 5.6-6.4 for best production.

---

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with a 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 8. SPINACH, MUSTARD, PARSLEY, OTHER GREENS

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 30-40 pounds of N per acre before planting and a side-dressing of 20-30 pounds at 3-4 weeks after planting. Calcium[2] should be extractable at 1,000-1,500 ppm, with magnesium[2] at 150-300 ppm and a soil pH of 5.8-6.8.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 25-30 pounds of N per acre before planting and a side-dressing of 20-30 pounds at 3-4 weeks after planting. The extractable calcium[2] level should be 1,500-2,500 ppm, with magnesium[2] at 300-500 ppm and a soil pH of 5.8-6.8.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply about 40 pounds of nitrogen per acre before planting and a side-dressing of 25-30 pounds of N at 3-4 weeks after planting. The extractable calcium[2] level should be 500-1,000 ppm, with a magnesium[2] level of 125-200 ppm and a soil pH of 5.6-6.4.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply about 50 pounds of nitrogen per acre before planting plus a side-dressing of about 30 pounds of N at 3-4 weeks after planting. Calcium[2] and magnesium[2] should be extractable at 400-800 ~~ppm~~ and 100-200 ppm respectively, with a soil pH of 5.6-6.4.

---

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 9. STRAWBERRIES

Light Alluvial Soils Only (fine sandy loam, very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	50 (VL)	50-150 (L)	150-250 (M)	250 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Strawberries grown on these soils under plastic mulch should require 30-50 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. If straw mulch is to be used, then 15-30 pounds of N should be applied before planting and 20-25 pounds applied just before the mulch is applied. These soils usually contain sufficient amounts of extractable calcium and magnesium for strawberries. The optimum pH is between 5.2 and 6.0.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	50 (VL)	50-150 (L)	150-250 (M)	250 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Strawberries grown on these soils under plastic mulch usually require 40-60 pounds of nitrogen per acre which is applied before planting and mulching. If straw mulch is used, then 30-40 pounds of N should be applied before planting and 20-30 pounds applied just before the mulch is applied. Strawberries have a relatively low extractable calcium[2] (400-600 ppm) and magnesium[2] (100-150 ppm) requirement on these soils. The optimum soil pH lies within the range of 5.2-6.0.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-130 (L)	130-220 (M)	220 (H)
Apply, lbs./acre (P_2O_5)	120	100	80	60

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Strawberries grown on these soils should require about 60 pounds of nitrogen, applied before the plastic mulch is applied. If straw mulch is to be used, then 30-40 pounds of N should be applied as a preplanting application and 20-30 pounds as a topdressing application just before the mulch is applied. An extractable calcium[2] level of 300-500 ppm and of magnesium[2] of 100-150 ppm should be sufficient on these soils. The soil pH should be between 5.2 and 6.0.

---

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with a 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 10. SWEET CORN

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 80-100 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 50-60 pounds of this nitrogen before planting and 30-40 pounds as side-dressing when the plants are 12-15 inches tall. Calcium[2] and magnesium[2] should be extractable at 1,000-1,500 ppm and 150-250 ppm respectively, with a soil pH of 5.5-6.5.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 60-80 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 40-50 pounds of this nitrogen before planting and 20-30 pounds as side-dressing when the plants are 12-15 inches tall. Calcium[2] should be extractable at 1,500-2,000 ppm, with magnesium[2] at 250-400 ppm and a soil pH of 5.5-6.5.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 50-60 pounds of nitrogen per acre before planting plus a side-dressing of 30-40 pounds of N when the plants are about 12 inches tall. The extractable calcium[2] level should be 400-800 ppm, with magnesium[2] at 125-200 ppm and a soil pH of 5.4-6.2.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 50-60 pounds of nitrogen per acre before planting plus 2 side-dressings of N: the first at 20-25 pounds per acre when the plants are about 12 inches tall and the second at the same rate when the plants are 3-4 feet tall. The optimum range for extractable calcium[2] is 400-600 ppm, with magnesium[2] at 100-150 ppm and a soil pH of 5.4-6.2.

---

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with a 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 11. SWEET PEPPER, EGGPLANT

Light Alluvial Soils (very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 50-70 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 30-40 pounds of this nitrogen before planting and 20-30 pounds as side-dressing when the plants begin to set fruit. Calcium[2] should be extractable at 1,000-1,500 ppm, and magnesium[2] at 150-300 ppm, with a soil pH of 5.6-6.6.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 40-60 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 25-40 pounds of this nitrogen before planting and 15-20 pounds as side-dressing when the plants begin to set fruit. Extractable calcium[2] should be 1,500-2,500 ppm, with magnesium[2] at 300-500 ppm and a soil pH of 5.6-6.6.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 40-50 pounds of nitrogen per acre before planting plus a side-dressing of 20-25 pounds of N when the plants begin to set fruit. The optimum extractable calcium[2] range is 500-1,000 ppm, with magnesium[2] at 150-200 ppm and a soil pH of 5.6-6.2.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 40-60 pounds of nitrogen per acre before planting plus a side-dressing of 20-30 pounds of N when the plants begin to set fruit. Calcium[2] should be extractable at 400-800 ppm, and magnesium[2] at 125-200 ppm, with a soil pH of 5.6-6.2.

---

[1] Extractable with 0.1 N + 0.03 N NH_4F at a soil:extractant ratio of 1:20.
[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.
NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 12. SWEET POTATOES

Light Alluvial Soils (sandy loam, fine sandy loam, very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	120	80	40	0

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	120	80	40	0

*Apply 0-30 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. In most cases, sweet potatoes grown on alluvial soils do not require nitrogen applications. In fact, if a particular soil contains as much as 1.5 percent organic matter, this may furnish excessive N to the crop during the growing season so that the plants will become excessively vegetative at the expense of storage root production. These soils usually contain sufficient amounts of extractable calcium and magnesium for good sweet potato production. A low soil pH (5.0 - 5.2) is preferable because of the danger of soil rot infection at a higher pH.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*Sweet potatoes grown on these soils do not usually require more than 30 pounds of N per acre. If the organic matter content is below 0.5 percent, then 35-40 pounds may be needed. Conversely, if the organic matter level is above 1.2 percent, the nitrogen application should be reduced to 15-20 pounds or less per acre. A soil pH of 5.0 - 5.2 is preferable because of the danger of soil rot infection at a higher pH. Sweet potatoes have a relatively low extractable calcium[2] (300-600 ppm) and magnesium[2] (100-150 ppm) requirement on these soils.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Sweet potatoes grown on these soils usually require 30-40 pounds of nitrogen per acre, the amount varying with the organic matter content and the degree of leaching of the nitrogen from the soil. If the organic matter level is below 0.5 percent, then the heavier rate of N suggested above may be necessary. A soil pH of 5.0 - 5.2 is preferable. A level of extractable calcium[2] of 300-500 ppm and of magnesium[2] of 80-120 ppm should be sufficient for sweet potatoes on these soils.

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[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with a 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 13. TOMATOES

Light Alluvial Soils (fine sandy loam, very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	150	120	90	60

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	150	120	90	60

*Apply 80-100 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. About half of this nitrogen (40-50 pounds) should be applied before planting, with 20-25 pounds of N applied as side-dressing at fruit setting of the first cluster and again at the third cluster. Calcium[2] should be extractable at 1,000-2,000 ppm, and magnesium[2] at 150-300 ppm, with a soil pH of 5.8 - 6.8.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	150	120	90	60

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	150	120	90	60

*Apply 60-100 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. About half of this nitrogen (30-50 pounds) should be applied before planting, with 15-25 pounds of N applied as side-dressing at fruit setting of the first cluster and again at the third cluster. Extractable calcium[2] should be 2,000-3,000 ppm, and magnesium[2] should be 300-500 ppm, with a soil pH of 5.8 - 7.0.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	150	120	90	60

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	150	120	90	60

*Tomatoes grown on these soils usually require 80-100 pounds of nitrogen per acre. About half this amount should be applied before planting, with the remainder applied in split applications as side-dressing (20-25 pounds of N at the first cluster and again at the third cluster of fruit). Extractable calcium[2] and magnesium[2] levels should lie within the ranges of 800-1,200 ppm calcium and 150-250 ppm magnesium, with a soil pH of 5.6 - 6.4.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	150	120	90	60

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	150	120	90	60

*Tomatoes grown on these soils generally require 80-120 pounds of nitrogen per acre. About half of the nitrogen should be applied before planting, with the other half applied as side-dressing in split applications (20-30 pounds at the first fruit cluster and a similar amount at the third cluster). On soils with deep sandy topsoils it may be desirable to apply a portion of the potassium as side-dressing applications also, expecially in an unusually wet season. Extractable calcium[2] should be 600-1,000 ppm, with magnesium[2] at 125-200 ppm and a soil pH of 5.6 - 6.4.

---

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with a 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 14. TURNIPS, RUTABAGAS, RADISHES, BEETS, KOHLRABI, CARROTS

Light Alluvial Soils (sandy loam, fine sandy loam, very fine sandy loam, silt loam)*

Phosphorus

Extractable[1] P from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*Apply 20-30 pounds of N per acre before planting and a side-dressing of 20-30 pounds at 3-4 weeks after planting. Calcium[2] and magnesium[2] should be extractable at 1,000-1,500 ppm and 150-300 ppm respectively, with a soil pH of 5.6-6.5.

Heavier Alluvial Soils (silty clay loam, clay loam)*

Phosphorus

Extractable[1] P from soil, ppm	60 (VL)	60-120 (L)	120-180 (M)	180 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	80 (VL)	80-160 (L)	160-240 (M)	240 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*Apply 15-20 pounds of N per acre before planting and a side-dressing of 15-20 pounds at 3-4 weeks after planting. Calcium[2] should be extractable at 1,500-2,500 ppm, with magnesium[2] at 300-500 ppm and a soil pH of 5.5-6.5.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[1] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*Apply 25-30 pounds of nitrogen per acre before planting, plus a side-dressing of 20-25 pounds of N at 2-3 weeks after planting. The levels of extractable calcium[2] and magnesium[2] should be 500-1,000 ppm and 125-200 ppm respectively, with a soil pH of 5.4-6.2.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	120	90	60	30

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	120	90	60	30

*Apply 30-40 pounds of nitrogen per acre before planting plus a side-dressing of 20-25 pounds of N at 2-3 weeks after planting. Calcium[2] and magnesium[2] should be extractable at 400-800 ppm and 100-200 ppm respectively, with a soil pH of 5.4-6.2.

---

[1] Extractable with 0.1 N + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

TABLE 15. WATERMELONS, CANTALOUPES

Light Alluvial Soils (loamy sand, sandy loam, fine sandy loam, very fine sandy loam)*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 0-50 pounds of N per acre, the amount varying inversely with the organic matter content of the soil. Apply 0-30 pounds of this nitrogen before planting and 0-20 pounds as side-dressing when the vines begin to run. These soils usually contain sufficient amounts of extractable calcium[2] and magnesium[2] for melons. The soil pH should be 5.0-5.5 for watermelons and 5.5-6.5 for cantaloupes.

Coastal Prairie, Flatwoods, and Loessial Hill and Mississippi Terrace Soils*

Phosphorus

Extractable[1] P from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	40 (VL)	40-100 (L)	100-160 (M)	160 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Use only the lighter-textured soils for melons. Apply 20-30 pounds of nitrogen per acre before planting, plus 15-20 pounds of N applied as side-dressing when the vines first begin to run. Extractable calcium[2] and magnesium[2] levels of 400-800 ppm and 125-200 ppm respectively should be sufficient. The soil pH should be 5.0-5.5 for watermelons and 5.4-6.2 for cantaloupes.

Coastal Plain Upland (Hill) Soils*

Phosphorus

Extractable[1] P from soil, ppm	20 (VL)	20-80 (L)	80-140 (M)	140 (H)
Apply, lbs./acre (P_2O_5)	100	80	60	40

Potassium

Extractable[2] K from soil, ppm	30 (VL)	30-90 (L)	90-150 (M)	150 (H)
Apply, lbs./acre (K_2O)	100	80	60	40

*Apply 30-40 pounds of nitrogen per acre before planting, plus 20-25 pounds of N as side-dressing when the vines first begin to run. Levels of 300-600 ppm and 100-150 ppm of extractable calcium[2] and magnesium[2] respectively should be sufficient. A soil pH of 5.0-5.5 is optimum for watermelons, but a range of 5.4-6.2 is best for cantaloupes.

---

[1] Extractable with 0.1 N HCl + 0.03 N NH_4F at a soil:extractant ratio of 1:20.

[2] Extractable with 0.1 N HCl at a soil:extractant ratio of 1:20.

NOTE: VL = very low; L = low; M = medium; H = high.

SUMMARY

A vast amount of information has been developed relative to the levels of easily extractable plant nutrients present in each of the seven general soil areas in Louisiana (fertility status). A considerable amount of knowledge has been gained also about the nutrient requirements of various vegetable crops grown under Louisiana conditions. An attempt has been made to interrelate this information so that a vegetable grower may have a soil sample analyzed by the LSU Soil Testing Laboratory in order to determine how fertile his particular soil is and how much of what kind of fertilizer he should apply in order to obtain near-maximum yields. It should be emphasized that other cultural operations are as important as proper fertilization in determining ultimate yields. It may also be noted that assistance is available, upon request, to anyone using the information supplied by this publication.

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March 1973

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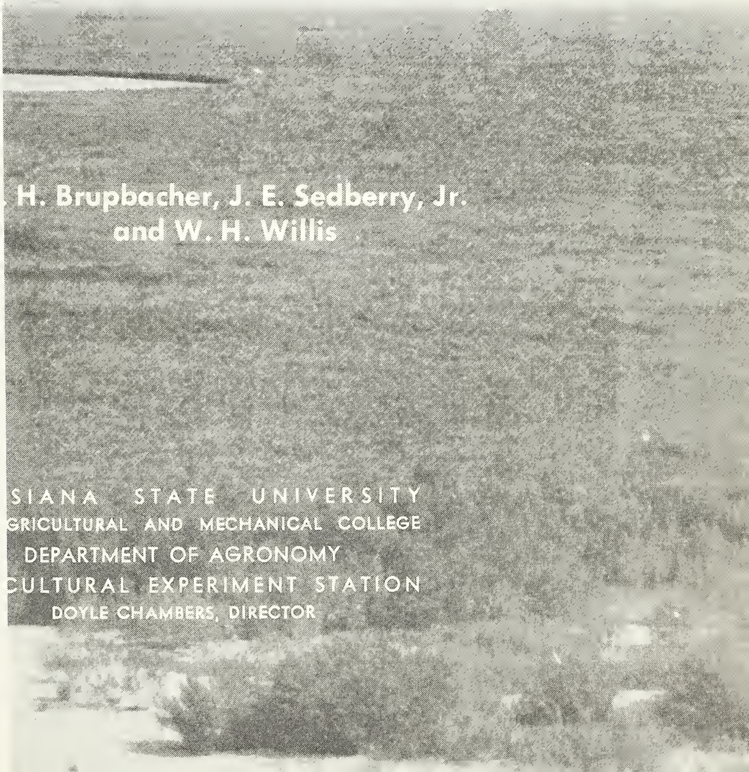
l Marshlands
# of Louisiana

l Properties of
the Soil Materials



H. Brupbacher, J. E. Sedberry, Jr.
and W. H. Willis

SIANA STATE UNIVERSITY
GRICULTURAL AND MECHANICAL COLLEGE
DEPARTMENT OF AGRONOMY
CULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

SUMMARY

A vast amount of information has been developed rel easily extractable plant nutrients present in each of the sev in Louisiana (fertility status). A considerable amount of gained also about the nutrient requirements of various ve under Louisiana conditions. An attempt has been mad information so that a vegetable grower may have a soil san LSU Soil Testing Laboratory in order to determine how soil is and how much of what kind of fertilizer he shoul obtain near-maximum yields. It should be emphasized th erations are as important as proper fertilization in determi It may also be noted that assistance is available, upon using the information supplied by this publication.

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1. Anonymous. 1956. Liming Facts and Figures. Plant No. 3, pp. 18-19.
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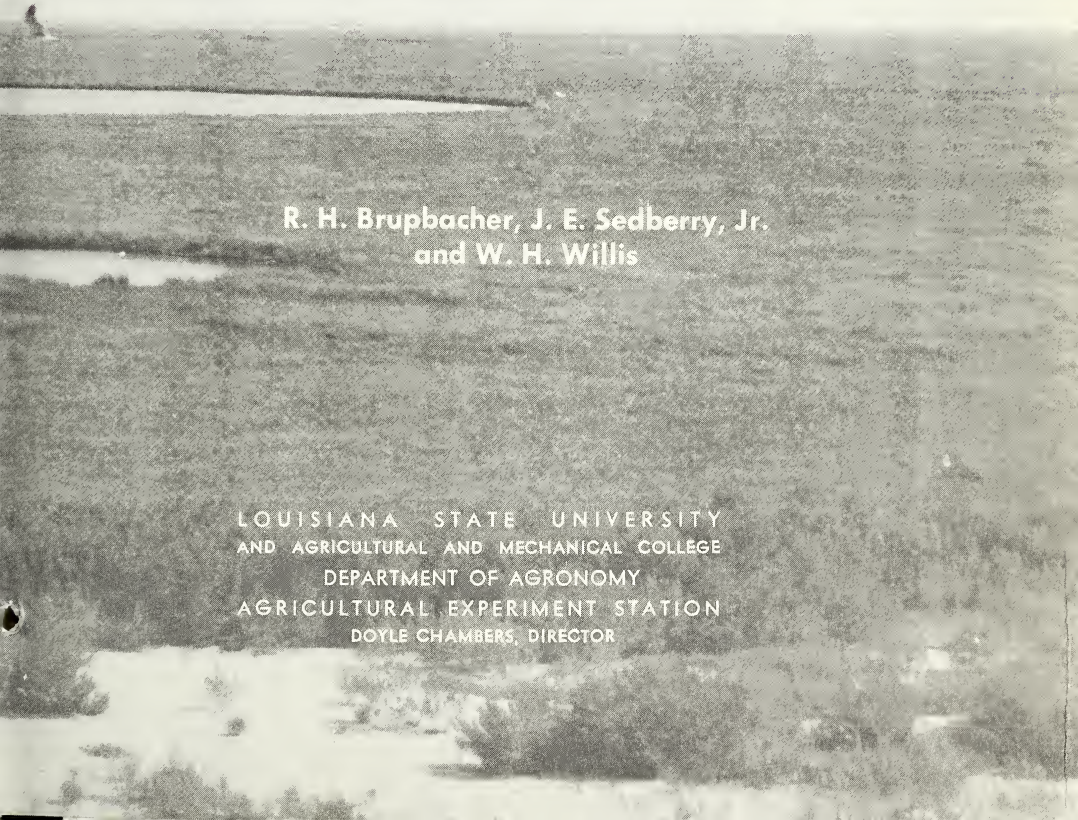
The Coastal Marshlands of Louisiana

Chemical Properties of the Soil Materials



R. H. Brupbacher, J. E. Sedberry, Jr.
and W. H. Willis

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE
DEPARTMENT OF AGRONOMY
AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

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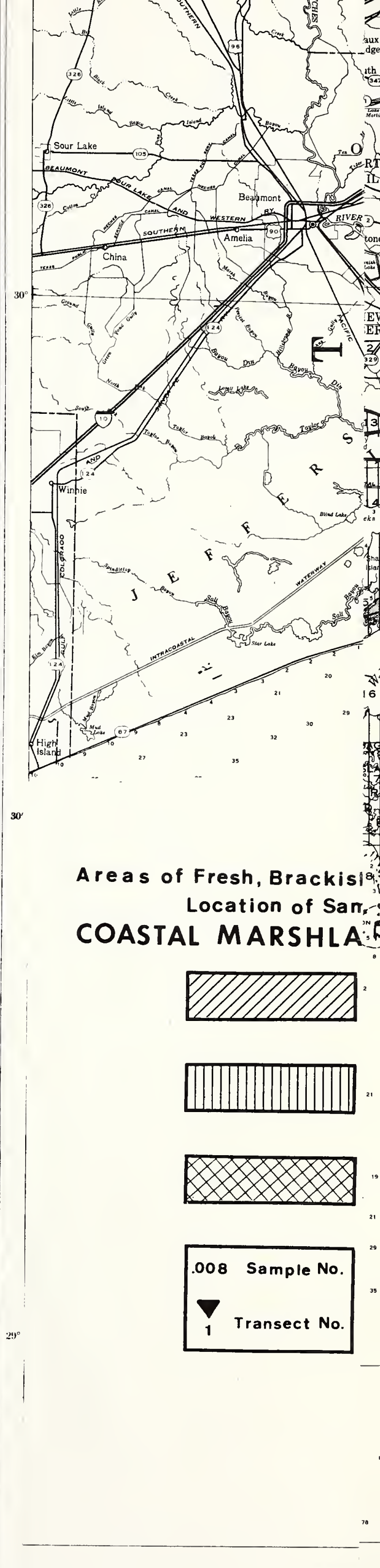

Sour Lake
Beaumont
Amelia
China
Winnie
High Island
Star Lake
Mud Lake
Blind Lake
INTRACOASTAL
WATERWAY
Taylor Bayou
Salt Bayou
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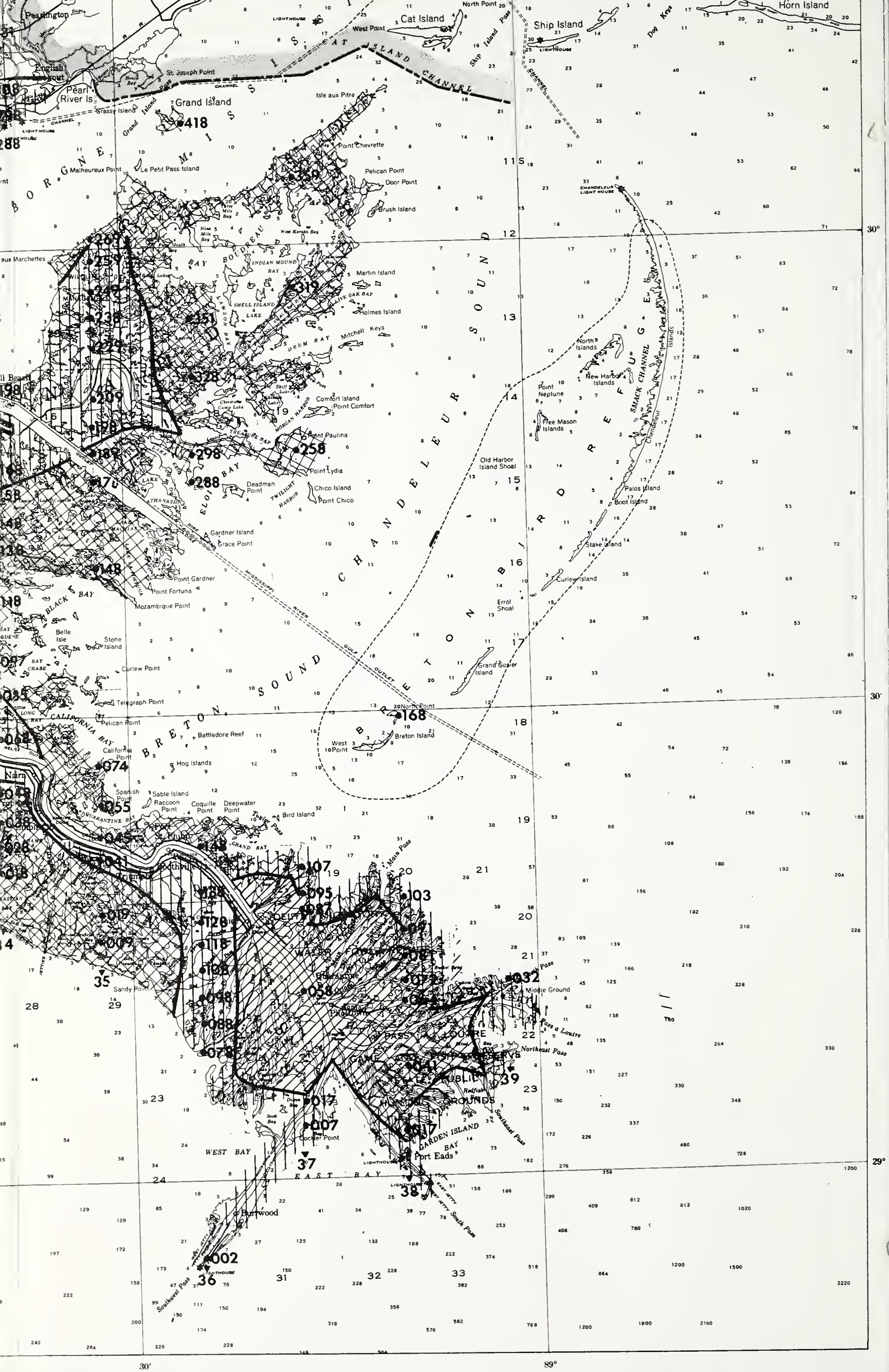
Pearlington
Cat Island
West Point
North Point
Ship Island
Ship Island Pass
Dog Keys
Horn Island
Lighthouse
English Lookout
Pearl River Is
St Joseph Point
Grassy Island
Grand Island
Isle aux Pitre
Point Chevrette
Pelican Point
Door Point
Brush Island
Malheureux Point
Le Petit Pass Island
Lake Borgne
Chandeleur Light House
Boudreau Bay
Indian Mound Bay
Lawson Bay
Shell Island Lake
Martin Island
Live Oak Bay
Holmes Island
Drum Bay
Mitchell Keys
Chandeleur Sound
North Islands
New Harbor Islands
Point Neptune
Free Mason Islands
Smack Channel
Chandeleur Islands
Chandeleur Refuge
Comfort Island
Point Comfort
Morgan Harbor
Treasure Bay
Point Paulina
Point Lydia
Old Harbor Island Shoal
Eloi Bay
Deadman Point
Twilight Harbor
Chico Island
Point Chico
Palos Island
Boot Island
Gardner Island
Grace Point
Stake Island
Mississippi River Gulf Outlet
Point Gardner
Point Fortuna
Mozambique Point
Curlew Island
Black Bay
Errol Shoal
Breton National Wildlife Refuge
Belle Isle
Stone Island
Curlew Point
Grand Gosier Island
Breton Sound
Telegraph Point
Pelican Point
California Bay
Battledore Reef
North Point
Breton Island
West Point
California Point
Hog Islands
Spanish Point
Sable Island
Raccoon Point
Coquille Point
Deepwater Point
Bird Island
Quarantine Bay
Fort St. Philip
Grand Bay
Main Pass
Boothville
Venice
Baptiste Collette Bayou
Delta National Wildlife Refuge
Sandy Point
Middle Ground
Pass a Loutre
Northeast Pass
Pass a Loutre Public Hunting Grounds
Redfish Bay
Southeast Pass
West Bay
Cocker Point
Garden Island Bay
Port Eads
East Bay
South Pass
East Jetty
Burrwood
Southwest Pass
30°
30'
29°
89°

The Coastal Marshlands of Louisiana
Chemical Properties of the Soil Materials

R. H. Brupbacher, J. E. Sedberry, Jr. and W. H. Willis[1]

INTRODUCTION

The coastal marsh area of Louisiana is a low, level, wet plain varying in width from 15 to 50 miles from north to south and extending along the coastline of the Gulf of Mexico from Sabine Lake on the west to the Mississippi River delta area of Plaquemines and St. Bernard Parishes on the east. The coastal marshes comprise approximately 4.5 million acres and support a luxuriant growth of grasses, sedges and other plants tolerant to fresh, brackish and salt water. Elevations range from sea level to 3 or 4 feet above sea level. These wet lands are made up of silty and clayey alluvial sediments deposited by the streams flowing into and across the marshes and by tidal channels and wave action. Large areas have a surface mantle of organic materials of varying thickness over the silty and clayey sediments (*7*).[2]

The increasing demand for food, fiber and oil crops has resulted in a need for more information on the chemical properties of soil materials in the coastal marshes of Louisiana. There is also an increasing interest in the use-potential of the wet lands of the coastal marshes for wildlife and recreational purposes. The economic importance of the multiple land uses and complementary enterprises of the Louisiana Coastal Region has been reviewed by Corty and published in A. E. A. Information Series No. 25 (*5*).

The data presented in this publication are the results of the chemical analyses of 366 samples of soil materials collected at specific locations in the Coastal Marshland area of Louisiana by the Louisiana Cooperative Wildlife Research Unit, Louisiana State University School of Forestry and Wildlife Management.

The primary objective of this investigation was to determine the chemical characteristics of soil materials from the Coastal Marshlands. A knowledge of the chemical composition of the soil materials is essential for the development of Coastal Marshland areas for specific uses.

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[1] Associate Professor, Professor of Agronomy, and Head, Department of Agronomy, respectively, Louisiana Agricultural Experiment Station, Baton Rouge.

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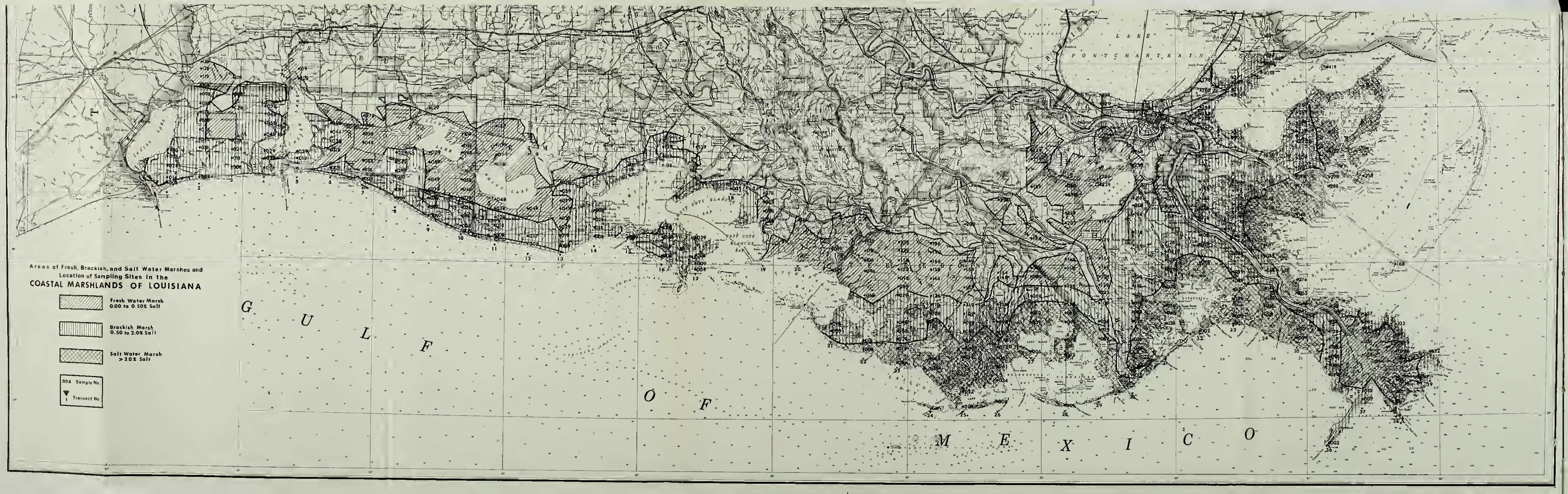

Areas of Fresh, Brackish, and Salt Water Marshes and Location of Sampling Sites in the
COASTAL MARSHLANDS OF LOUISIANA

The Coastal Marshlands of Louisiana
Chemical Properties of the Soil Materials

R. H. Brupbacher, J. E. Sedberry, Jr. and W. H. Willis[1]

INTRODUCTION

The coastal marsh area of Louisiana is a low, level, wet plain varying in width from 15 to 50 miles from north to south and extending along the coastline of the Gulf of Mexico from Sabine Lake on the west to the Mississippi River delta area of Plaquemines and St. Bernard Parishes on the east. The coastal marshes comprise approximately 4.5 million acres and support a luxuriant growth of grasses, sedges and other plants tolerant to fresh, brackish and salt water. Elevations range from sea level to 3 or 4 feet above sea level. These wet lands are made up of silty and clayey alluvial sediments deposited by the streams flowing into and across the marshes and by tidal channels and wave action. Large areas have a surface mantle of organic materials of varying thickness over the silty and clayey sediments (*7*).[2]

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PROCEDURES

Method of Sampling and Identification of Soil Materials

Samples of soil materials were collected at approximately 2-mile intervals on 39 north-south transects. These transects were located 7.5 miles apart from Sabine Lake to the Mississippi River delta areas of Plaquemines and St. Bernard Parishes. Predetermined longitude and latitude lines were selected as transect and reference lines, respectively. The latitude lines were established on or near the Louisiana coast. The intersection of a latitude line and a transect was used as a reference point from which each sampling site was measured. The longitude and latitude lines used as transects and reference lines are listed in Table 1, and are shown on the map of the Coastal Marshlands on the sheet opposite Page 1.

Sampling sites were established along each transect at 0.25-mile intervals starting from the reference point. A numbering system for sampling sites was devised which indicated the transect and also the distance from a reference point to the sampling site. The first two digits identify the transect, the next two digits the number of 2-mile intervals from the reference point and the last digit designates the 0.25-mile station within the 2-mile interval.

The samples of soil material were collected during a 16-day period from August 7 to August 22, 1968. Two helicopters were used in collecting the samples of soil materials. The samples were taken from the surface to a depth of about 8 inches (20.3 cm) and placed in plastic bags, sealed, identified and stored under refrigeration at 2C until the samples were classified as to type of soil material and prepared for chemical analyses.

Classification of the Type of Marsh and Soil Materials

The different types of vegetation growing in the Coastal Marshlands have been influenced by the degree of salinity of the areas and the salt tolerance of the plants that grow in the marshlands. Penfound and Hathaway (*11*) described the types of vegetation growing under different salinity conditions. Those investigators established the following salinity classes: Fresh Water Marsh, 0.0 to 0.5 per cent salt; Brackish Marsh, 0.5 to 2.0 per cent salt; Salt Water Marsh, more than 2.0 per cent salt. Each sampling site in this study was classified as to type of marsh by Chabreck (*3, 4*) and Palmisano (*10*) on the basis of the vegetative types described by Penfound and Hathaway.

The dominant morphological characteristics of the soil materials from the Coastal Marshlands are the dark brown and black colors of the organic soils and of the mineral soils containing high amounts of organic matter, and the gray colors that are due to waterlogged, reduced soil conditions (*6*). The textural classification of the soil materials in the Coastal Marshlands is based on the kind and amount of mineral material, the content of organic matter and the degree of decomposition of the organic materials.

Table 1.-Location of sampling sites in the Coastal Marshlands of Louisiana.

Transect number	Transect line	Reference line	Distance and direction to starting point from reference line
	longitude	latitude	miles
1	90° 47' 30"	29° 30'	14-N
2	93° 40'	29° 45'	2-S
3	93° 32' 30"	29° 45'	Same
4	93° 25'	29° 45'	Same
5	93° 17' 30"	29° 45'	Same
6	93° 10'	29° 45'	Same
7	93° 2' 30"	29° 45'	2-S
8	92° 55'	29° 30'	12-N
9	92° 47' 30"	29° 30'	8-N
10	92° 40'	29° 30'	6-N
11	92° 32' 30"	29° 30'	4-N
12	92° 25'	29° 30'	2-N
13	92° 17' 30"	29° 30'	2-N
14	92° 10'	29° 30'	4-N
15	92° 2' 30"	29° 30'	4-N
16	91° 55'	29° 30'	Same
17	91° 47' 30"	29° 30'	2-S
18	91° 40'	29° 30'	16-N
19	91° 32' 30"	29° 30'	Same
20	91° 25'	29° 30'	Same
21	91° 17' 30"	29° 15'	Same
22	91° 10'	29° 00'	14-N
23	91° 2' 30"	29° 00'	12-N
24	90° 55'	29° 00'	2-N
25	90° 47' 30"	29° 00'	2-N
26	90° 40'	29° 00'	2-N
27	90° 32' 30"	29° 00'	14-N
28	90° 25'	29° 00'	2-N
29	90° 17' 30"	29° 00'	4-N
30	90° 10'	29° 00'	6-N
31	90° 2' 30"	29° 7' 30"	4-N
32	89° 55'	29° 15'	2-N
33	89° 47' 30"	29° 15'	4-N
34	89° 40'	29° 15'	2-N
35	89° 32' 30"	29° 15'	2-S
36	89° 25'	28° 45'	12-N
37	89° 17' 30"	29° 00'	2-N
38	89° 10'	29° 00'	Same
39	89° 2' 30"	29° 00'	8-N

Source: Ph.D. Dissertation, Robert Henry Chabreck, Louisiana State University. 1970.

The soil materials used in this investigation were classified as peats, mucks or clays. Organic materials that consisted of fibrous and only slightly decomposed plant parts were classified as peats. Organic materials that were decomposed to the extent that most plant fibers were destroyed were classified as mucks. Clays containing relatively high amounts of organic matter occur in the Coastal Marshlands and also on the natural levees along bayous that flow into and across the marshes. An estimation of the proportions of clay, silt, sand, straw or peaty and mucky materials and the stage of decomposition of the organic materials was used as a basis for classifying the other soil materials. Soil materials classified as mineral included the sandy clays, silty clays, clays, mucky clays and peaty clays. The more organic soil materials were classified as clayey mucks, clayey peats, mucks or peats.

Preparation of the Samples for Chemical Analyses

The samples of soil materials saturated with water were placed in plastic-lined stainless steel pans for air-drying. The air-dried soil materials were ground mechanically in a Bico pulverizer, Type UA, so that the particles passed a U. S. Standard Sieve No. 10 with 2-millimeter openings. The undecomposed organic material present in the sample was ground in a Wiley mill so that the material passed a 0.5-mm sieve. The finely divided organic material was then mixed with the sample. Soil reaction (pH) and soluble salts (the summation of measured cations and anions) were determined on this material.

A 25-gram sub-sample of the air-dried soil materials was taken from the samples previously prepared and ground in a mortar so as to pass a U. S. Standard Sieve No. 35 with 0.5-millimeter openings. The samples were stored in screw-cap bottles. The sub-samples were used for the determination of organic carbon (C), organic nitrogen (N) and acid-extractable phosphorus (P), sodium (Na), magnesium (Mg), calcium (Ca) and potassium (K).

Methods of Analyses of Soil Materials

Organic carbon was determined in a dry combustion apparatus by a method described by Allison et al. (*1*). The combustion tube was heated to 950°C. Purified oxygen was passed through the system and the C was converted to carbon dioxide (CO_2). Fifteen minutes were required for complete combustion. The CO_2 gas was trapped in absorption bulbs containing ascarite and was weighed. Carbon dioxide was determined on each sample gravimetrically and reported as per cent C on an oven-dry basis. The percentage of organic matter was calculated by multiplying the per cent of organic C by the factor 1.724. This factor was found by Wilson and Staker (*13*) to be acceptable for calculating the percentage of organic matter from the percentage of organic C in peats.

Organic nitrogen in the soil materials was determined by the Kjeldahl method as modified by Gunning and Hibbard (*14*). The procedure was also modified to use boric acid for the absorption of ammonia as described by Meeker and Wagner *(8)*. Organic N is reported on an oven-dry basis.

Since relatively little information was available on the reliability of solutions to extract quantities of cations present in the marshland soil materials, two extractants were used in this study. The extractants were water and O.1 *N* hydrochloric acid (HCl). Anions were extracted only with water.

Water-soluble cations and anions were determined by a modification of the methods of Richards et al. (*12*), using 1 part of soil to 5 parts of water. The soil and water suspension was agitated for 30 minutes on a mechanical shaking machine. The suspension was allowed to stand overnight and filtered through a Pasteur-Chamberlain filter. Aliquots of the water extract were used for the determination of the cations and anions. Sodium, Mg^{++}, Ca^{++}, and K^+ were determined on instruments described in Louisiana Agricultural Experiment Station Bulletin No. 632 (*2*). Chlorides (Cl^-) were determined by titrating an aliquot of the extract with silver nitrate in the presence of potassium chromate. Sulphates ($SO_4^=$) were determined by a modification of the method described by Metson (*9*). An aliquot of the extract, containing 0 to 120 ppm $SO_4^=$, was acidified with a solution of 1:1 HCl, and $SO_4^=$ was precipitated as barium sulphate ($BaSO_4$) by the addition of sized barium chloride ($BaCl_2$) crystals. The turbidity of the $BaSO_4$ suspension was measured on a Baush and Lomb Spectrophotometer. The amount of $SO_4^=$ present in the extract was determined by reference to a calibration curve obtained by plotting the optical density readings of the spectrophotometer against the $SO_4^=$ concentrations of standard reference solutions. The determinations of carbonate ($CO_3^=$) and bicarbonate (HCO_3^-) were made by titrating an aliquot of the water extract with 0.01 *N* H_2SO_4 to a pH of about 8.2 using phenolphthalein as the indicator, and then continuing the titration to a pH of 4.0 with bromphenol blue as the indicator. The titration to the phenolphthalein endpoint indicated the amount of $CO_3^=$ present and the titration to pH 4.0 indicated the amount of HCO_3^-. Soluble carbonates are not usually present in soils until the pH exceeds 9.5. Bicarbonates may occur at much lower pH values (*9*). The amounts of total water-soluble salts in the samples of soil material were calculated by summing the water-soluble cation and anion concentrations.

The analytical methods and procedures used to determine soil reaction and acid-extractable P, Na, Mg, Ca and K are described in Louisiana Agricultural Experiment Station Bulletin No. 632 (*2*). Phosphorus was determined by extracting a sample of soil with a solution of 0.10 *N* HCl containing 0.03 *N* NH_4F. A soil-to-solution ratio of 1:20 and an extracting period of 15 minutes were used to determine extractable P. Sodium, Mg, Ca and K were determined by extracting a sample of soil with a 0.10 *N* HCl solution using a soil-to-solution ratio of 1:20. The extracting time was 15 minutes. Soil reaction (pH) was determined by using a pH-meter and a slurry of soil and distilled water at a soil-to-solution ratio of approximately 1:2.

Acid-extractable P, Na, Mg, Ca and K and water-soluble cations and anions were determined on air-dried soil materials and are reported on an air-dry basis.

Distribution of Soil Materials and Marsh Types

Thirty-six per cent of the samples from the Coastal Marshlands were classified as mineral soil materials; 64 per cent were classified as organic soil material. The percentages of mineral and organic samples of soil materials from three areas of the Coastal Marshlands are presented in Table 2. The percentages of samples from the western and eastern areas of the Coastal Marshlands comprising Cameron and Vermilion on the west and Plaquemines and St. Bernard Parishes on the east, were almost equally divided between mineral and organic soil materials. Eighty-four per cent of the samples from Iberia, St. Mary, Terrebonne, Lafourche, Jefferson, St. Charles and St. John Parishes in the central area of the Coastal Marshlands were classified as organic. Forty-two per cent of the samples of the organic soil materials from these parishes were classified as peats.

Table 2.-The percentages of mineral and organic samples of soil materials in the Coastal Marshlands of Louisiana.

Location parishes	No. of samples	Mineral samples	Organic samples
		-------per cent	---------
Cameron & Vermilion	104	51.9	48.1
Plaquemines & St. Bernard	105	49.5	50.5
Iberia, St. Mary, Terrebonne, Lafourche, Jefferson, St. Charles and St. John	157	15.9	84.1

Palmisano (*10*) and Chabreck (*3, 4*) used vegetation as an index for classifying the salinity types of marsh that occur in the coastal areas of Louisiana. They found that the Salt Water Marsh generally parallels the coastline. It occupies a narrow strip approximately one-half mile wide from Sabine Lake to Vermilion Bay. Approximately 45,500 acres of Salt Water Marsh occur in this area, which includes Cameron Parish and the western part of Vermilion Parish. The Salt Water Marsh comprises a relatively small acreage in the Vermilion Bay area. A relatively large area of Salt Water Marsh, approximately 750,000 acres, occurs along the coastline extending from St. Mary Parish to St. Bernard Parish. The Brackish Marsh generally occurs inland from the Salt

Water Marsh and comprises an area of approximately 1,200,000 acres. The Fresh Water Marsh occupies an area of approximately 1,870,000 acres. It is bordered on the south by the Brackish Marsh and on the north by the Coastal Prairie soils occurring in the southwestern section and the Alluvial soils of the Mississippi River floodplain in the southern and southeastern sections of the state.

RESULTS AND DISCUSSION

Organic Matter and Nitrogen Contents of the Soil Materials

The organic matter and organic N contents and the C:N ratios of the soil materials are summarized in Table 3 and presented in detail for each sample in Table 9 in the Appendix.

The data in Table 3 indicate that the lowest amounts of organic matter were found in the clay-textured soil materials. These materials, which included sandy clays, silty clays and clays, contained less than 10 per cent organic matter and from 0.09 to 0.62 per cent N. The mineral soil materials classified as mucky clays and peaty clays contained from 10 to 16 per cent organic matter and 0.28 to 0.88 per cent N.

The organic soil materials contained more than 16 per cent organic matter. The clayey mucks and clayey peats contained from 16 to 27 per cent organic matter and from 0.43 to 1.22 per cent N. The organic matter contents of the mucks and peats decreased from Fresh Water to Brackish to Salt Water areas of the Coastal Marshlands. The highest amounts of organic matter, 27 to 89 per cent, were present in the Fresh Water mucks and peats. The higher amounts of organic matter found in the Fresh Water mucks and peats may have been due to the more luxuriant growth of plant species occurring in the area. The average organic matter contents of the mucks and peats from the Fresh Water, Brackish and Salt Water areas were 66, 50 and 45 per cent, respectively.

The organic N contents of soil materials containing more than 10 per cent organic matter were consistently higher in the Fresh Water Marsh than they were in the Brackish and Salt Water Marshes. The average N contents of the mucky clays and peaty clays varied from 0.46 per cent in the Salt Water Marsh to 0.63 per cent in the Fresh Water Marsh. Soil materials classified as clayey mucks and clayey peats contained from 0.70 per cent N in the Salt Water Marsh to 0.81 per cent in the Fresh Water Marsh. As noted in Table 3, the largest variation in N contents occurred in the mucks and peats. The mucks and peats in the Fresh Water, Brackish and Salt Water Marshes had average N contents of 2.27, 1.67 and 1.45 per cent, respectively.

The C:N ratio is an indicator of the degree of organic decomposition that has taken place in the soil materials. The data presented in Table 3 show that as the organic matter and N contents increased, the ratio of C:N also increased. The C:N ratios of the mineral soil ma-

Table 3.-Organic matter and N contents and C:N ratios of soil materials in the Coastal Marshlands of Louisiana.

Type of marsh	No. of samples	Organic Matter Range %	Organic Matter Average %	Organic N Range %	Organic N Average %	C/N Ratio Range	C/N Ratio Average
MINERAL SOIL MATERIALS							
Sandy Clays, Silty Clays and Clays							
Fresh Water	20	1.50- 8.90	5.46	0.09-0.62	0.28	8.0-17.9	11.7
Brackish	20	1.57- 9.45	6.90	0.09-0.49	0.28	9.9-23.4	14.5
Salt Water	17	3.83- 9.95	7.46	0.10-0.39	0.28	11.7-23.4	15.8
Mucky Clays and Peaty Clays							
Fresh Water	13	11.57-15.86	13.70	0.38-0.88	0.63	9.7-18.2	12.8
Brackish	30	10.01-15.20	12.41	0.31-0.68	0.50	10.5-20.6	14.6
Salt Water	16	10.05-16.00	12.94	0.28-0.72	0.46	13.1-26.0	16.8
ORGANIC SOIL MATERIALS							
Clayey Mucks and Clayey Peats							
Fresh Water	13	16.10-25.77	20.00	0.63-1.13	0.81	11.0-23.7	14.7
Brackish	31	16.03-26.25	20.42	0.53-1.22	0.78	12.3-21.7	15.6
Salt Water	13	16.91-25.26	20.41	0.43-0.98	0.70	12.2-22.8	17.4
Mucks and Peats							
Fresh Water	67	27.36-89.03	66.34	0.95-3.35	2.27	10.3-28.2	17.1
Brackish	85	27.70-85.72	49.82	0.84-3.10	1.67	10.4-36.2	17.8
Salt Water	13	28.39-76.75	45.13	0.76-2.97	1.45	14.4-43.8	19.8

terials varied from 8:1 to 26:1, and those of the organic soil materials varied from 10:1 to 44:1.

The C:N ratios of the soil materials in the Fresh Water Marsh were lower than those in the Brackish and Salt Water Marshes. The average C:N ratios of the clay-textured soil materials in the Fresh, Brackish and Salt Water Marshes were 12:1, 15:1 and 16:1, respectively. The average ratio of C:N varied from 17:1 in samples of Fresh Water mucks and peats to 20:1 in Salt Water mucks and peats. Apparently, the degree of decomposition of the organic materials in the Brackish and Salt Water Marshes was not as advanced as it was in the Fresh Water Marsh.

Soil Reaction (pH)

Soil reaction (pH) of the soil materials from Fresh, Brackish and Salt Water Marshes is presented in Tables 4, 5 and 6 and in detail for each sample in Table 9 in the Appendix.

The reaction of the soil materials ranged from extremely acid, pH 3.7, to moderately alkaline, pH 7.5. The pH of the soil materials generally decreased with increasing amounts of organic matter. The reaction of the clay-textured soil materials ranged from pH 4.0 to 7.5. The range for the mucks and peats was pH 3.7 to 6.7.

Total Water-Soluble Salts and Water-Soluble Cations and Anions

The total water-soluble salts and water-soluble cations and anions of soil materials from Fresh, Brackish and Salt Water Marshes are presented in Tables 4, 5 and 6 and in detail for each sample in Table 10 in the Appendix.

The amount of total water-soluble salts determined the salinity classes of the soil materials. The percentages of water-soluble salts increased from areas of Fresh Water Marsh to areas of Salt Water Marsh. Lytle (7) described the Coastal Marshlands as areas undergoing constant changes in salinity and vegetative types. The salinity and type of vegetation in any area of the marshlands depend mainly upon the length of time that salt water or fresh water has influenced the area. Salts brought into the Coastal Marshlands by tides are removed from some areas by rainfall and by the floodwater of fresh water streams. Since environmental adjustments of many plants to changes in salinity conditions are slow, it is not uncommon to find plants in the Coastal Marshlands growing in areas that have a salt content outside the ranges of their normal salt tolerance.

The data presented in Tables 4, 5 and 6 and in Table 10 indicate that the amounts of salts in the soil materials from the Coastal Marshlands increased with increases in the organic matter content. The lowest amounts of soluble salts occurred in the clay-textured soil materials. These materials contained the following amounts of total soluble salts: Fresh Water clays, 0.12 to 0.57 per cent; Brackish clays, 0.53 to 1.99 per cent; Salt Water clays, 2.02 to 5.09 per cent. The salt contents of the clay-textured soil materials agree with the salt tolerance values established by Penfound and Hathaway (*11*) for areas of the Coastal Marshlands classified as Fresh, Brackish and Salt Water Marshes. Higher amounts of soluble salts occurred in the soil materials classified as mucky clays and peaty clays, with a range of 0.22 to 0.90 per cent in the Fresh Water Marsh, 0.60 to 3.94 per cent in the Brackish Marsh and 3.01 to 6.27 per cent in the Salt Water Marsh. The organic soil materials classified as clayey mucks and clayey peats contained 0.19 to 1.64 per cent water-soluble salts in the Fresh Water Marsh, 0.60 to 7.35 per cent in the Brackish Marsh and 2.62 to 10.54 per cent in the Salt Water Marsh. The mucks and peats contained the highest amounts of water-soluble salts. The amounts of salts in the Fresh Water mucks and peats ranged from 0.33 to 7.17 per cent, with the Brackish mucks and peats containing 1.10 to 13.00 per cent and the Salt Water mucks and peats containing 4.99 to 21.45 per cent water-soluble salts.

Since the total water-soluble salts were determined on air-dried soil materials, relatively high values were obtained on the samples that contained large amounts of organic matter with low bulk-densities. These samples also contained large amounts of water at the time the samples were collected.

The data presented in Tables 4, 5 and 6 also show that the concentrations of water-soluble Na^+, Mg^{++}, Ca^{++} and K^+ in all soil materials increased from Fresh Water to Brackish to Salt Water Marshes. The largest increase from Fresh Water to Salt Water Marsh was noted in the concentration of Na^+. The amounts of water-soluble Na^+ in the clay-textured soil materials ranged from 124 to 1,580 ppm in the Fresh Water Marsh, from 1,120 to 5,680 ppm in the Brackish Marsh and from 5,110 to 16,500 ppm in the Salt Water Marsh. The highest amounts of Na^+ occurred in the mucks and peats. The amounts of water-soluble Na^+ in these materials ranged from 351 to 22,491 ppm in the Fresh Water Marsh and from 15,788 to 56,750 ppm in the Salt Water Marsh.

The amounts of water-soluble Na^+, Mg^{++}, Ca^{++} and K^+ increased with increases in the organic matter content of the soil materials. The lowest amounts of water-soluble cations generally occurred in the clay-textured soil materials, with the highest amounts present in the mucks and peats. The mucky clays, peaty clays, clayey mucks and clayey peats contained intermediate amounts of water-soluble cations.

The soil materials in the Coastal Marshlands contained larger amounts of Na^+ than of Mg^{++}, Ca^{++} or K^+. The average amounts of water-soluble Na^+ varied from 738 ppm in the Fresh Water clays to 30,011 ppm in Salt Water mucks and peats. The Mg^{++} contents varied from 92 ppm in the Fresh Water clays to 3,843 ppm in the Salt Water mucks and peats.

The Brackish and Salt Water Marshes contained lesser amounts of water-soluble Ca^{++} than Mg^{++}. However, the Ca^{++} contents in the Fresh Water clays, mucky clays and peaty clays were higher than were the Mg^{++} contents. The Ca^{++} varied from 272 to 292 ppm and the Mg^{++} varied from 92 to 166 ppm in these soil materials. The average Ca^{++} and Mg^{++} contents in the organic soil materials from the Fresh Water Marsh were approximately equal.

All soil materials in the Coastal Marshlands contained lower amounts of water-soluble K^+ than Ca^{++}. The lowest amounts of K^+ occurred in the clay-textured soil materials, with an average of 93 ppm in the Fresh Water clays and 365 ppm in the Salt Water clays. The highest amounts of water-soluble K^+ occurred in the mucks and peats. The average K^+ contents in the mucks and peats varied from 189 ppm in the Fresh Water Marsh to 1,141 ppm in the Salt Water Marsh.

The data presented in Tables 4, 5 and 6 further indicate that the soil materials in the Coastal Marshlands contained relatively high amounts of Cl^- and $SO_4^=$, but somewhat lesser amounts of HCO_3^-. The concentrations of Cl^- and $SO_4^=$ in the soil materials increased from the Fresh Water to Brackish to Salt Water areas of the Coastal Marshlands. The data also indicate that with increasing amounts of organic matter from the clays to the mucks and peats, there was a corresponding increase in the concentration of Cl^- and $SO_4^=$. The highest amounts of Cl^- and $SO_4^=$ occurred in the soil materials classified as mucks and peats, with the lowest amounts occurring in the clay-textured soil materials.

Table 4.-Soil reaction (pH), total water-soluble salts and the water-soluble cations and anions of soil materials in the Fresh Water Marsh of Louisiana.

	Mineral Soil Materials				Organic Soil Materials			
	Clays[1]		Mucky and Peaty Clays[2]		Clayey Mucks and Clayey Peats[2]		Mucks and Peats[3]	
	Range	Average	Range	Average	Range	Average	Range	Average
	pH							
Soil reaction	5.1-7.5	-	5.1-6.2	-	4.3-5.9	-	4.1-6.0	-
	per cent							
Total water-soluble salts	0.12-0.57	0.33	0.22-0.90	0.51	0.19-1.64	0.72	0.33-7.17	1.76
	ppm							
Na^+	124-1580	738	195-1770	1148	132-2970	1240	351-22491	4118
Mg^{++}	10-250	92	50-430	166	60-850	344	88-4542	827
Ca^{++}	92-620	292	112-525	272	112-640	321	144-3424	856
K^+	24-170	93	36-240	99	46-240	114	59-719	189
Cl^-	500-2000	1040	500-3200	1663	700-8400	2527	900-25300	7230
$SO_4^=$	56-1032	526	225-3600	880	310-4890	1864	175-16218	4042
HCO_3^-	237-1539	524	30-2974	808	59-2663	807	7-2929	728

[1] The sandy clays, silty clays and clays were represented by a total of 20 samples.

[2] The mucky and peaty clays and clayey mucks and clayey peats were represented by 13 samples each.

[3] The mucks and peats were represented by a total of 67 samples.

Table 5.-Soil reaction (pH), total water-soluble salts and the water-soluble cations and anions of soil materials in the Brackish Marsh of Louisiana.

	Mineral Soil Materials				Organic Soil Materials			
	Clays[1]		Mucky and Peaty Clays[2]		Clayey Mucks and Clayey Peats[3]		Mucks and Peats[4]	
	Range	Average	Range	Average	Range	Average	Range	Average
	pH							
Soil reaction	4.0-7.5	-	4.8-6.9	-	4.1-6.7	-	3.7-6.6	-
	per cent							
Total water-soluble salts	0.53-1.99	1.34	0.60-3.94	1.99	0.60-7.35	3.27	1.10-13.00	5.88
	ppm							
Na^+	1120-5680	3505	1440-11350	5268	1160-20100	8529	1420-41438	16304
Mg^{++}	80-810	402	100-1600	670	130-3250	1325	147-5250	2577
Ca^{++}	186-878	368	136-1500	398	206-1600	593	104-3500	1148
K^+	78-389	200	78-590	275	50-840	396	80-1438	620
Cl^-	1828-8700	6091	1700-19600	9415	1200-48400	15888	2000-67600	28636
$SO_4^=$	675-4779	1951	1233-6810	3042	1212-12300	5387	900-23007	8939
HCO_3^-	30-1835	797	59-5829	903	0-1746	594	0-5658	618

[1] The sandy clays, silty clays and clays were represented by a total of 20 samples.

[2] The mucky and peaty clays were represented by a total of 30 samples.

[3] The clayey mucks and clayey peats were represented by a total of 31 samples.

[4] The mucks and peats were represented by a total of 85 samples.

Table 6.-Soil reaction (pH), total water-soluble salts and the water-soluble cations and anions of soil materials in the Salt Water Marsh of Louisiana.

	Mineral Soil Materials				Organic Soil Materials			
	Clays[1]		Mucky and Peaty Clays[2]		Clayey Mucks and Clayey Peats[3]		Mucks and Peats[3]	
	Range	Average	Range	Average	Range	Average	Range	Average
	pH							
Soil reaction	5.1-7.4	-	5.0-6.8	-	4.5-6.8	-	4.9-6.7	-
	per cent							
Total water-soluble salts	2.02-5.09	2.42	3.01-6.27	4.33	2.62-10.54	5.55	4.99-21.45	10.03
	ppm							
Na^+	5110-16500	7354	7840-17900	12628	6570-30950	15467	15788-56750	30011
Mg^{++}	490-1460	848	1160-2475	1560	970-4340	2178	2350-7088	3843
Ca^{++}	280-1850	515	424-2200	947	554-1730	1083	915-3300	1522
K^+	230-550	365	454-1000	646	490-1180	666	174-2338	1141
Cl^-	9400-27800	12339	12200-28500	20406	11900-55100	27315	24800-130500	52854
$SO_4^=$	1320-6750	3589	3075-11664	6277	3765-12600	7977	1335-14952	9576
HCO_3^-	222-1746	927	44-2621	883	89-1953	838	89-3495	1285

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[1] The sandy clays, silty clays and clays were represented by a total of 17 samples.
[2] The mucky and peaty clays were represented by a total of 16 samples.
[3] The clayey mucks and clayey peats and the mucks and peats were represented by a total of 13 samples each.

The data in Table 7 indicate that the water-soluble Cl^- constituted the largest proportion of the anions measured. Chlorides comprised from 49 to 83 per cent of the anions. Samples of soil materials from the Salt Water Marsh had higher percentages of Cl^- than did those from the Brackish and Fresh Water Marshes. Water-soluble $SO_4^=$ constituted a smaller proportion of the anion composition of the soil materials than did the Cl^-. Sulphates were found to be intermediate between the Cl^- and HCO_3^-. Water-soluble $SO_4^=$ constituted from 15 to 36 per cent of the measured anions. The data showed that as the percentage of the Cl^- increased, there was a corresponding decrease in the percentage of $SO_4^=$ and HCO_3^-. The HCO_3^- comprised from 2 to 25 per cent of the anions measured. Samples from the Fresh Water Marsh had a significantly higher percentage of HCO_3^- than did the samples from the other types of marsh.

In the event that consideration is given to reclaiming the marshlands for agricultural purposes knowledge of the total water-soluble salts and the fractionation of these salts into their various components would be a major criterion in evaluating the potential use of the area. It is apparent from the analytical data obtained that many of the samples of soil materials contained excessive amounts of total salts for the profitable production of most agricultural crops, and inherent difficulties would be encountered in reclaiming these areas.

Table 7.-Water-soluble anions expressed as a percentage of the measured anions in soil materials in the Coastal Marshlands of Louisiana.

Type of marsh	Cl^-	$SO_4^=$	HCO_3^-
	-------------------per cent	--------------------	
	Sandy Clays, Silty Clays and Clays		
Fresh Water	50	25	25
Brackish	69	22	9
Salt Water	73	21	6
	Mucky Clays and Peaty Clays		
Fresh Water	50	26	24
Brackish	70	23	7
Salt Water	74	23	3
	Clayey Mucks and Clayey Peats		
Fresh Water	49	36	16
Brackish	73	24	3
Salt Water	76	22	2
	Mucks and Peats		
Fresh Water	60	34	6
Brackish	75	23	2
Salt Water	83	15	2

Dilute Acid-Extractable P, Na, Mg, Ca and K Contents of the Soil Materials

The amounts of extractable P, Na, Mg, Ca and K in the soil materials from Fresh Water, Brackish and Salt Water Marshes are summarized in Table 8 and presented in detail in Table 9 in the Appendix.

The amounts of extractable P varied from 5 to 386 ppm. The extractable P contents were higher in the clay-textured soil materials than in the soil materials containing higher amounts of organic matter. The highest amounts of extractable P occurred in the clay-textured soil materials from the Salt Water Marsh. Smaller amounts of P were found in the clay-textured soil materials from the Fresh Water and Brackish Marshes. The lowest amounts of extractable P occurred in the soil materials classified as mucks and peats, with values varying from 15 to 220 ppm. Undoubtedly, some of the P in the mucks and peats was associated with the organic matter, and the extracting solution employed in this investigation may have removed only a small amount of the organic fraction of P. Soil materials classified as mucky clays, peaty clays, clayey mucks and clayey peats contained intermediate amounts of extractable P.

The amounts of dilute acid-extractable Na, Mg and K increased from Fresh Water to Brackish to Salt Water Marshes. The Ca contents, however, were higher in the soil materials from the Fresh Water Marsh than they were in samples from the Brackish and Salt Water Marshes. The data suggest that the fresh water and the salt water environments influenced the kinds of cations in the soil materials.

The amounts of dilute acid-extractable Na, Mg, Ca and K increased with increases in the organic matter content of the soil materials. The lowest amounts of extractable cations generally occurred in the clay-textured soil materials and the highest amounts occurred in the mucks and peats.

Relatively large variations were found in the amounts of all of the extractable cations in the soil materials from the Coastal Marshlands. The largest variation was noted in the Na contents of samples from the Fresh Water, Brackish and Salt Water Marshes. The average Na contents varied from 1,320 ppm in the Fresh Water clays to 5,566 ppm in the Fresh Water mucks and peats, from 5,294 ppm in the Brackish clays to 20,562 ppm in the Brackish mucks and peats and from 10,698 ppm in the Salt Water clays to 32,658 ppm in the Salt Water mucks and peats.

The amounts of dilute acid-extractable Mg were lower than were the amounts of Na in all soil materials. The lowest amounts of Mg occurred in the clay-textured soil materials, with 100 to 2,990 ppm in the Fresh Water Marsh, 1,120 to 3,410 ppm in the Brackish Marsh and 1,640 ppm to 3,840 ppm in the Salt Water Marsh. The highest amounts of dilute acid-extractable Mg were found in the Salt Water mucks and peats, with a range of 3,890 to 12,430 ppm.

The soil materials from the Fresh Water Marsh generally contained

Table 8.-The extractable[1/] elements of the soil materials in the Coastal Marshlands of Louisiana.

Type of marsh	No. of samples	Phosphorus		Sodium		Magnesium		Calcium		Potassium	
		Range ppm	Av. ppm	Range ppm	Av. ppm	Range ppm	Av. ppm	Range ppm	Av. ppm	Range ppm	Av. ppm
MINERAL SOIL MATERIALS											
Sandy Clays, Silty Clays and Clays											
Fresh Water	20	5-371	127	120-3250	1320	100-2990	1685	296-4270	1842	80-720	317
Brackish	20	35-371	201	1390-9800	5294	1120-3410	2188	204-1800	974	204-1140	739
Salt Water	17	133-386	235	7040-22450	10698	1640-3840	2698	490-5000	1448	582-1270	931
Mucky Clays and Peaty Clays											
Fresh Water	13	35-244	100	270-2930	1840	1460-3210	2209	900-5460	2028	160-708	383
Brackish	30	24-264	157	2780-16000	8186	1745-4540	2975	360-3880	1222	466-1830	888
Salt Water	16	55-283	205	9400-18100	13851	2360-3999	2930	572-3430	1776	844-1830	1212
ORGANIC SOIL MATERIALS											
Clayey Mucks and Clayey Peats											
Fresh Water	13	15-112	64	200-5500	2146	1160-4360	2615	794-5570	3046	130-428	321
Brackish	31	14-264	137	2860-28150	12365	2620-8780	4117	580-4620	1533	422-1700	974
Salt Water	13	100-264	181	9100-39200	18522	1900-5986	3851	806-6800	2286	678-2000	1271
Mucks and Peats											
Fresh Water	67	15-183	55	680-20600	5566	580-7950	2974	500-11333	5354	78-948	305
Brackish	85	15-224	90	6150-42700	20562	2850-12400	5774	588-11270	3158	1120-2260	1134
Salt Water	13	49-220	118	18250-56800	32658	3890-12430	6794	384-6180	3364	496-2600	1630

[1/] Phosphorus was extracted with a solution of 0.10 N HCl containing 0.03 N ammonium fluoride. A soil-to-solution ratio of 1:20 was used. Na, Mg, Ca and K were extracted with a 0.1 N HCl solution using a soil-to-solution ratio of 1:20.

larger amounts of dilute acid-extractable Ca than Mg. However, the Ca contents were lower than the Mg contents in the Brackish and Salt Water Marshes. The average concentrations of acid-extractable Ca in the Fresh Water clays and Fresh Water mucks and peats were 1,842 and 5,354 ppm, respectively. The Mg contents were 1,685 ppm in the Fresh Water clays and 2,974 ppm in the Fresh Water mucks and peats. The Salt Water Marsh contained an average of 1,448 ppm Ca in the clay-textured soil materials and 3,364 ppm Ca in the mucks and peats. The Mg contents of these materials were higher, with 2,698 ppm in the clay-textured soil materials and 6,794 ppm in the mucks and peats.

The amounts of dilute acid-extractable K were lower than were the amounts of Ca, Mg or Na in soil materials from the Fresh Water, Brackish and Salt Water Marshes, with the highest amounts of K occurring in the Salt Water Marsh. The K contents ranged from 582 to 1,270 ppm in the Salt Water clays and from 496 to 2,600 ppm in the Salt Water mucks and peats. The lowest amounts of K occurred in the Fresh Water Marsh, with ranges of 80 to 720 ppm in the clay-textured soil materials and 78 to 948 ppm in the mucks and peats.

SUMMARY

Samples of soil materials taken to a depth of about 8 inches at 366 sites in the Coastal Marshlands of Louisiana were collected at 2-mile intervals on 39 north-south transect lines. These transects were located 7.5 miles apart from Sabine Lake to the Mississippi River delta areas of Plaquemines and St. Bernard Parishes. Each sampling site was classified into one of the following types of marsh: Fresh, Brackish or Salt Water. Soil materials from each site were classified as clays, peats or mucks.

Organic C and N, soil reaction (pH), soluble salts, water-soluble and dilute acid-extractable Na, Mg, Ca and K, water-soluble Cl^-, $SO_4^=$ and HCO_3^- and acid-extractable P were determined on each of the samples.

The clay-textured soil materials, which included sandy clays, silty clays and clays, contained from 1.5 to 10 per cent organic matter. Mineral soil materials classified as mucky clays and peaty clays contained from 10 to 16 per cent organic matter. Soil materials containing more than 16 per cent organic matter were classified as organic. The clayey mucks and clayey peats contained from 16 to 27 per cent organic matter. The highest amounts of organic matter, 27 to 89 per cent, occurred in the Fresh Water mucks and peats.

Organic N increased with increases in the organic matter content. The organic N contents were generally higher in samples of soil materials from the Fresh Water Marsh than they were in samples from Brackish and Salt Water Marshes.

The C:N ratios of soil materials in the Fresh Water Marsh were lower than those in the Brackish and Salt Water Marshes. The data suggested that organic matter in the Fresh Water Marsh was at a more advanced stage of decomposition.

The soil reaction, pH, of the samples ranged from 3.7 to 7.5.

Total water-soluble salts in the soil materials increased with increases in the organic matter. The lowest amounts of soluble salts occurred in the clay-textured soil materials, with ranges of 0.12 to 0.57 per cent in the Fresh Water clays, from 0.53 to 1.99 per cent in the Brackish clays and from 2.02 to 5.09 per cent in the Salt Water clays. The mucks and peats contained the highest amounts of water-soluble salts; they varied from an average of 1.76 per cent in the Fresh Water Marsh to 10.03 per cent in the Salt Water Marsh.

The concentrations of water-soluble Na^+, Mg^{++}, Ca^{++} and K^+ increased from Fresh to Brackish to Salt Water areas of the Coastal Marshlands. As the organic matter contents of the samples increased, there was a corresponding increase in all of the water-soluble cations.

The soil materials from the Coastal Marshlands contained relatively high amounts of Cl^- and $S0_4^=$, and lesser amounts of $HC0_3^-$. The concentration of Cl^- and $S0_4^=$ increased from Fresh to Brackish to Salt Water areas.

The amounts of dilute acid-extractable P in the samples of soil materials varied from 5 to 386 ppm. The amounts of extractable P were higher in the clay-textured soil materials than they were in the soil materials containing higher amounts of organic matter. The highest amounts of extractable P occurred in the clay-textured soil materials from the Salt Water Marsh.

The amounts of dilute acid-extractable Na, Mg and K increased from the Fresh to Brackish to Salt Water Marsh. The Ca contents, however, were highest in the soil materials from the Fresh Water Marsh. The amounts of extractable cations also increased with increases in organic matter in the soil materials.

Relatively large variations were found in the amounts of all of the extractable cations in the soil materials from the Coastal Marshlands. Extractable cations varied as follows: Na, 120 to 56,800 ppm; Mg, 100 to 12,430 ppm; Ca, 204 to 11,333 ppm; and K, 78 to 2,600 ppm.

Two extracting solutions, water and 0.10 *N* HCl, are useful in determining the chemical characteristics of soil materials in the Coastal Marshlands. Since soils in the Coastal Marshlands are frequently saturated with varying amounts of fresh and salt water, knowledge of the total water-soluble salts and the fractionation of these salts into their various components would be a major criterion in evaluating the potential use of the area for wildlife habitat and agricultural crop production. It is apparent from the analytical data obtained that many of the samples of soil materials contained excessive amounts of total salts for the profitable production of most agricultural crops, and inherent difficulties would be encountered in reclaiming these areas. Knowledge of the dilute acid-extractable cations and acid-extractable P is useful in determining the fertility status of the soils in the marshlands. The great variation found in the amounts of extractable P, Na, Mg, Ca and K indicated that in order to determine the fertility status of the soil materials from the Coastal Marshlands, it would be necessary to analyze representative samples from specific areas. Generalizations would be too broad to be of much value.

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APPENDIX

Table 9 .--Sample location and chemical properties of soil materials in the Coastal Marshlands of Louisiana.

MINERAL SOIL MATERIALS

Sample Location	Organic Matter %	Organic C %	Organic N %	C/N Ratio	Extractable[1/] elements					pH
					P	K	Ca	Mg	Na	
					ppm					
				Sandy Clays						
3-078	4.03	2.34	0.14	16.7	5	84	844	450	1280	5.9
3-088	1.50	0.90	0.09	10.0	15	180	2740	450	2580	7.5
5-149	1.57	0.91	0.08	12.0	35	204	204	1120	3520	4.0
8-033	2.05	1.19	0.12	9.9	136	298	700	1290	2990	6.9
32-268	7.45	3.32	0.19	17.5	288	564	5870	3550	6010	7.5
				Silty Clays						
26-061	3.83	2.22	0.10	22.2	332	582	3570	2770	9950	7.2
35-019	8.69	5.04	0.39	12.9	298	1116	660	2720	8900	6.4
36-078	4.98	2.89	0.20	14.5	322	740	1150	2220	3400	6.0
38-018	3.41	1.98	0.09	22.0	366	206	4200	1660	720	7.1
38-041	4.33	2.51	0.11	22.8	322	198	4310	1770	580	7.1
38-103	7.71	4.47	0.25	17.9	298	600	1960	2460	1920	6.5
					Clays					
1-008	7.65	4.44	0.27	16.4	210	960	480	2285	6000	6.4
1-018	8.16	4.74	0.51	9.3	210	720	1900	2735	2700	7.5
1-028	8.75	5.08	0.62	8.2	102	460	880	1920	2600	6.1
2-098	7.89	4.58	0.39	11.7	15	242	1320	1750	2870	5.7
2-108	3.53	2.05	0.16	12.8	41	194	394	600	630	5.8
3-018	8.71	5.10	0.49	10.4	105	650	1202	3410	3580	6.0
3-108	6.14	3.56	0.27	13.2	15	146	1962	1630	1290	6.2
4-018	8.83	5.12	0.47	10.9	181	1140	620	3310	8000	6.8
5-109	6.71	3.89	0.29	13.4	17	262	580	1280	2560	5.5
5-119	2.34	1.36	0.13	10.5	15	80	296	100	340	5.1
6-008	6.84	3.97	0.27	14.7	212	502	1800	2750	4210	6.5
6-028	8.48	4.92	0.38	12.9	107	514	1520	2370	1900	5.6
7-008	8.19	4.75	0.39	12.2	181	1108	1280	3660	9950	6.8
7-018	6.81	3.95	0.35	11.3	159	632	1800	2990	1280	6.0
8-009	6.14	3.56	0.25	14.2	159	1140	1000	3390	9800	6.7
9-009	9.95	5.77	0.34	17.0	178	1270	1160	3840	11900	6.2
10-038	7.89	4.58	0.57	8.0	73	440	820	2473	2300	6.0
11-129	8.90	5.60	0.39	14.4	32	78	1240	840	290	5.5
12-008	9.19	5.33	0.39	13.7	133	926	740	3660	11150	5.5
12-108	6.02	3.49	0.29	12.0	10	128	1080	660	160	5.2
13-019	8.02	4.65	0.36	12.9	97	598	1040	2910	3250	5.4
14-008	6.88	3.99	0.34	11.7	112	588	1320	2890	2820	5.9
15-009	6.07	3.52	0.28	12.6	142	904	1080	2990	8300	6.4
15-089	8.19	4.75	0.33	14.4	148	430	1458	2100	1400	6.5
22-004.5	7.26	4.21	0.18	23.4	125	910	24000	3260	7750	7.4
22-008	8.34	4.84	0.23	21.0	152	852	1080	2620	11900	6.1
22-096	7.69	4.46	0.39	11.4	93	262	3460	2550	800	6.3
23-004	4.59	2.76	0.21	13.1	249	1000	400	1880	8200	6.6
23-019	7.44	4.32	0.37	11.7	229	1000	800	1940	6000	6.7
24-058	6.64	3.85	0.27	14.3	332	868	5000	2660	10450	6.8
25-021.5	5.67	3.29	0.22	15.0	240	780	1352	2060	9550	6.8
26-051	9.74	5.65	0.34	16.6	254	928	976	2190	9850	5.1
31-058	7.74	4.49	0.24	18.7	254	674	1698	1490	5810	6.3
32-243	3.67	2.13	0.11	19.4	322	792	2940	2670	4120	7.8
33-028	2.93	1.70	0.12	14.2	237	880	3100	2140	5400	7.2
33-133	8.36	4.85	0.30	16.2	171	560	320	1555	6100	6.2
34-028	8.02	4.65	0.23	20.2	371	792	1138	1670	6380	6.9
34-085	7.40	4.29	0.25	17.2	356	762	540	1740	5980	6.8
34-138	8.21	4.76	0.28	17.0	224	618	1644	1640	7040	6.4
34-158	6.28	3.64	0.30	12.1	234	744	2090	2100	7690	6.2
35-055	9.19	5.33	0.24	22.2	268	1200	656	2550	10550	5.8
35-074	5.81	3.37	0.23	14.7	386	1196	490	3640	22450	7.1
35-148	5.79	3.36	0.21	16.0	210	1080	1144	1920	9000	6.2

(Continued)

Table 9 .-(Continued) Sample location and chemical properties of soil materials in the Coastal Marshlands of Louisiana.

MINERAL SOIL MATERIALS

Sample Location	Organic Matter %	Organic C %	Organic N %	C/N Ratio	Extractable[1] elements					pH
					P	K	Ca	Mg	Na	
					ppm					
				Clays (Continued)						
35-189	2.53	1.47	0.09	16.3	332	604	3120	3020	5050	7.8
36-002	3.26	1.89	0.12	15.8	293	822	3030	2930	4350	8.1
36-088	9.45	5.48	0.25	21.9	322	748	834	1950	2910	5.2
36-098	8.53	4.95	0.39	12.7	259	630	1650	2380	6270	6.2
36-298	8.53	4.95	0.36	13.8	210	926	1122	2470	10700	6.5
36-418	6.78	3.93	0.26	15.1	220	716	616	2410	12550	6.1
37-058	6.03	3.50	0.26	13.5	234	220	3240	1810	540	6.4
37-107	5.88	3.41	0.27	12.6	268	414	1510	1520	1390	5.8
38-017	3.62	2.10	0.15	14.0	366	238	2720	1440	610	6.9
38-064	6.53	3.79	0.23	16.5	264	176	2930	1800	590	6.9
38-072	2.91	1.69	0.16	10.6	244	316	3650	2160	410	7.1
38-081	4.93	2.86	0.16	17.9	371	238	4270	1770	380	7.2
38-091	4.53	2.63	0.19	13.8	317	236	4330	2060	880	7.4
39-032	3.48	2.02	0.18	11.2	327	564	2360	2560	1880	6.9
				Mucky Clays						
1-038	12.29	7.13	0.53	13.5	115	940	400	3205	6800	6.6
2-058	14.31	8.03	0.58	13.8	30	566	3060	4330	6350	6.1
3-008	13.72	7.96	0.61	13.1	83	1004	1880	4540	5800	6.3
3-028	10.91	6.33	0.40	15.8	64	466	1240	2690	2780	5.8
4-015	12.31	7.14	0.68	10.5	122	1830	894	4280	16000	6.2
4-028	14.73	8.54	0.67	12.8	190	1300	780	3975	11000	6.8
5-019	12.34	7.16	0.55	13.0	127	594	1760	3970	4120	6.2
7-048	12.74	7.39	0.62	11.9	35	370	1760	2970	1580	5.5
8-019	12.96	7.52	0.61	12.3	81	754	844	2490	3720	5.0
10-108	12.27	7.23	0.69	10.5	39	240	1500	1560	900	5.7
13-029	15.03	8.72	0.59	14.8	115	660	2920	4790	3050	5.9
27-006	14.71	8.53	0.47	18.2	195	1002	1394	2580	13650	5.7
27-049	14.72	8.54	0.63	13.6	229	1600	1364	3050	13350	5.2
28-063	10.26	5.95	0.43	13.8	259	1650	2890	3290	14500	6.6
29-069	12.12	7.03	0.50	14.1	283	1150	620	2610	10450	6.6
30-198	15.93	9.24	0.59	15.7	127	540	2100	2875	5700	5.4
32-278	11.00	6.38	0.43	14.8	251	972	436	2680	5950	5.8
34-068	10.01	5.81	0.34	17.1	254	896	778	2430	9800	6.5
36-288	10.71	6.21	0.25	24.8	210	680	862	1920	9300	5.8
37-258	10.90	6.32	0.28	22.6	181	1124	750	2920	15650	5.8
				Peaty Clays						
1-014	10.88	6.31	0.51	12.4	146	840	360	2315	7000	5.7
2-008	11.16	6.47	0.44	14.7	120	726	3880	2940	3120	6.7
4-008	15.17	8.80	0.66	13.3	205	880	980	2635	8000	6.4
4-047	15.67	9.10	0.63	14.4	107	320	1220	2265	2400	6.2
4-078	12.88	7.47	0.48	15.6	24	520	1080	2165	7000	6.2
7-028	15.86	9.20	0.80	11.5	60	612	1600	3190	2450	5.7
8-039	11.57	6.71	0.52	12.9	72	358	1440	2240	1880	5.6
9-019	12.15	7.05	0.55	12.8	212	1460	810	4110	12550	5.7
9-039	12.31	7.14	0.60	11.9	81	354	2360	3210	2930	6.1
10-088	14.74	8.55	0.88	9.7	85	240	900	1595	1600	5.5
11-028	11.13	6.05	0.46	13.2	147	960	1080	3960	7600	5.8
11-048	15.45	8.96	0.65	13.8	45	352	1840	2250	2350	5.1
12-017	14.62	8.48	0.59	14.4	113	702	1520	3880	4980	5.8
13-009	11.84	6.87	0.58	11.8	118	760	1640	3100	2850	6.0
13-049	12.12	7.03	0.52	13.5	84	160	1800	2310	2750	6.0
21-079	15.84	9.19	0.65	14.1	123	416	4080	1730	1180	5.9
23-029	11.04	6.40	0.31	20.6	234	1020	1800	1745	7000	6.7
25-069	14.86	8.62	0.60	14.4	176	1160	2632	3310	11900	6.5
26-034	14.22	8.25	0.43	19.2	198	874	1582	2960	14400	5.8
27-039	12.21	7.08	0.51	13.9	200	1390	1112	3999	18100	6.5
27-099	14.77	8.57	0.72	11.9	117	242	5460	1460	270	5.6

(Continued)

Table 9 .-(Continued) Sample location and chemical properties of soil materials in the Coastal Marshlands of Louisiana.

MINERAL SOIL MATERIALS

Sample Location	Organic Matter %	Organic C %	Organic N %	C/N Ratio	Extractable 1/elements					pH
					P	K	Ca	Mg	Na	
							ppm			
Peaty Clays (Continued)										
28-078	10.05	5.83	0.43	13.6	229	930	3030	2920	14700	6.6
28-118	16.00	9.42	0.72	13.1	268	1830	3230	3440	17400	6.2
30-166	14.72	8.54	0.64	13.3	210	740	1080	2410	7000	5.8
31-038	15.46	8.97	0.50	17.9	55	1028	19400	2360	11050	6.8
32-248	13.90	8.06	0.49	16.5	215	1096	1398	3190	10500	5.7
33-039	10.93	6.34	0.45	14.1	229	1650	1734	3148	14000	6.8
33-126	11.67	6.77	0.55	12.3	171	920	1640	2800	12000	6.5
33-134	10.54	6.11	0.52	11.8	166	780	1260	2240	9000	6.9
33-254	15.20	8.82	0.50	17.6	127	940	760	3065	14000	5.5
33-255	14.02	8.13	0.49	16.6	185	800	678	2195	7000	5.2
33-261	12.40	7.19	0.43	16.7	156	780	808	2475	10000	5.7
33-269	14.02	8.13	0.47	17.3	156	1030	684	2865	15000	4.9
34-097	10.45	6.06	0.40	15.2	251	1032	3430	2620	9400	6.1
34-168	10.52	6.10	0.31	19.7	264	660	802	2280	7240	6.1
34-198	10.38	6.02	0.40	15.1	176	668	1060	1970	8650	4.8
35-178	13.83	8.02	0.37	21.7	166	1290	1188	2520	13800	6.2
35-332	11.24	6.52	0.23	28.4	171	486	346	1380	4970	4.3
36-351	10.24	5.94	0.36	16.5	239	1016	1282	2310	12750	6.5
37-087	12.38	7.18	0.59	12.2	244	708	918	2430	2520	5.5
37-095	11.90	6.90	0.38	18.2	210	596	1490	1510	1110	5.3
37-319	10.29	5.97	0.35	17.1	205	844	572	2430	15300	5.0
37-359	15.71	9.11	0.35	26.0	161	864	1114	2740	13950	5.7
ORGANIC SOIL MATERIALS										
Clayey Mucks										
2-048	25.41	14.74	0.87	16.9	30	822	4620	5800	9300	6.3
2-078	17.24	10.00	0.63	15.9	14	560	3460	4430	7600	6.1
4-058	21.56	12.51	0.70	17.9	29	1140	1900	4425	12000	6.0
4-068	18.49	10.73	0.70	15.3	27	980	2000	4035	11000	6.4
9-049	17.03	9.88	0.53	18.6	48	428	2482	3740	2750	6.1
9-069	18.24	10.58	0.69	15.3	44	392	3604	4360	2160	5.9
10-028	25.75	14.94	1.07	14.0	107	1120	1180	8780	11000	6.1
26-078	17.27	10.02	0.82	12.2	264	1138	1236	3210	9100	5.7
26-234	18.55	10.76	0.98	11.0	54	304	5560	1590	200	5.3
35-198	19.00	11.02	0.75	14.7	176	1060	2120	3500	17600	6.3
Silty Peats										
34-331	25.77	14.95	0.63	23.7	110	368	794	2060	3210	4.5
36-328	25.26	14.65	0.71	20.6	100	2000	1748	5986	39200	5.8
Clayey Peats										
1-043	26.25	15.23	1.16	13.1	137	1260	820	5425	20000	6.2
2-138	21.14	12.26	0.98	12.5	100	296	2270	3770	5500	5.0
5-029	25.84	14.99	0.89	16.8	113	1090	1600	6680	28150	6.3
7-078	17.86	10.36	0.76	13.6	15	130	2220	1160	550	5.4
8-049	17.34	10.06	0.82	12.3	72	462	1280	3490	4890	5.1
8-059	19.00	11.02	0.85	13.0	58	470	1680	3810	3060	5.5
10-005	17.38	10.08	0.57	17.7	146	1700	866	4380	17000	6.7
10-014	19.42	11.27	0.76	14.8	120	1140	796	3965	13000	5.7
10-018	25.96	15.06	0.99	15.2	144	1080	580	3885	8000	6.4
10-098	17.96	10.42	0.90	11.6	49	240	1300	1825	2200	5.6
11-008	19.17	11.12	0.66	16.8	151	1196	1000	4390	17800	5.9
11-038	16.17	9.38	0.73	12.8	35	398	2220	3160	2190	5.2
13-039	16.10	9.34	0.64	14.6	37	380	2482	3980	3730	5.4
14-018	17.57	10.19	0.76	13.4	83	656	1640	3290	3250	5.3
15-079	18.02	10.45	0.62	16.9	176	792	1680	3760	9200	5.8

(Continued)

Table 9 .-(Continued) Sample location and chemical properties of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Organic Matter %	Organic C %	Organic N %	C/N Ratio	Extractable[1/] elements					pH
					P	K	Ca	Mg	Na	
					ppm					
Clayey Peats (Continued)										
16-008	18.83	10.92	0.83	13.2	193	548	1360	2620	2860	5.2
16-018	22.10	12.82	0.87	14.7	115	626	2180	3650	5900	5.8
17-004	22.14	12.83	0.98	13.1	146	1350	1278	4460	20600	5.5
17-009	19.26	11.17	0.78	14.3	73	1190	1398	5033	18000	6.3
18-012	16.62	9.64	0.76	12.7	76	378	4080	3060	820	5.7
19-048	26.02	15.67	1.05	14.9	56	422	3460	3510	3730	5.4
21-009	20.21	11.72	0.54	21.7	264	1034	1720	3360	8200	6.2
21-099	18.00	10.44	0.74	14.1	112	354	5000	1830	490	5.6
22-018	21.55	12.50	0.81	15.4	151	1270	1800	4380	22500	5.5
22-068	25.15	14.59	1.13	12.9	68	408	3658	3460	2650	5.3
23-039	21.64	12.55	0.79	15.9	190	1000	1120	4405	20000	6.7
23-049	16.03	9.30	0.65	14.3	205	1100	1954	3585	13000	6.3
24-048	17.36	10.07	0.64	15.7	220	1340	2098	4150	21650	6.4
24-098	24.95	14.44	0.98	14.7	118	1210	6800	4810	16300	6.4
26-087	18.88	10.95	0.73	15.0	156	914	2320	3340	9150	6.1
26-118	22.34	12.96	0.77	16.8	142	856	1268	3480	8300	4.1
28-098	20.86	12.10	0.69	17.5	259	678	1598	1900	9550	6.4
28-207	24.24	14.06	1.00	14.1	34	246	5570	1360	550	5.4
29-239	23.12	13.41	0.79	17.0	110	186	1410	1250	3040	4.3
30-018	18.15	10.53	0.78	13.5	154	1100	600	4065	19000	4.9
31-048	20.45	11.86	0.66	18.0	137	1760	4250	3680	17950	5.6
31-098	22.43	13.01	0.64	20.3	161	1760	1558	4120	22000	4.5
32-238	19.45	11.28	0.57	19.8	215	1004	1208	2780	9150	4.5
33-049	18.87	10.95	0.67	16.3	163	1600	1386	3865	18000	6.1
33-126.5	17.21	9.98	0.63	15.8	181	1020	1406	3590	17000	6.4
33-129	18.94	10.99	0.78	14.1	156	1100	1180	3790	17000	6.1
33-273	22.97	13.32	0.73	18.2	205	1160	1080	4015	12000	6.1
34-018	21.98	12.75	0.67	19.0	195	1118	2830	3770	16900	5.7
34-118	23.08	13.39	0.65	20.6	190	1166	1674	3770	16900	5.1
34-148	16.96	9.84	0.73	13.5	176	1000	1602	3760	17400	5.5
34-288	20.57	11.93	0.57	20.9	156	884	1026	2750	9600	4.5
35-063	16.91	9.81	0.43	22.8	190	710	806	3530	18250	6.8
Mucks										
2-038	29.57	17.15	1.22	14.1	30	552	2180	4570	6150	5.2
3-038	29.81	17.29	0.96	18.0	41	566	2920	5840	9350	5.4
9-029	35.20	20.42	1.41	14.5	108	934	2920	6820	11600	5.7
10-048	41.22	23.91	1.81	13.2	22	440	4500	5890	6900	5.9
10-058	56.55	32.80	2.70	12.1	49	440	6700	7950	7900	5.8
12-048	36.46	21.15	1.49	14.2	20	470	4080	5120	2210	5.3
22-133	31.17	18.08	1.49	12.1	98	442	500	2150	1180	5.4
32-148	40.60	23.55	2.27	10.4	129	1098	3630	4770	15300	4.7
Peaty Mucks										
2-088	27.94	16.21	0.89	18.2	67	1088	1406	5180	17000	5.9
6-038	32.77	19.01	1.11	17.1	61	1076	2532	6940	20800	5.9
6-058	33.22	19.27	1.37	14.1	46	564	2794	5320	4790	5.4
9-129	34.84	20.20	1.23	16.4	83	178	2360	1470	588	5.2
10-008	33.80	19.32	1.30	14.9	142	1760	1818	6070	25000	6.6
11-018	27.70	16.07	0.96	16.7	195	1152	1720	5440	15550	5.9
11-088	32.24	18.70	1.30	14.4	33	302	1720	2460	1860	4.9
13-069	30.64	17.77	1.06	16.8	53	614	2034	2920	4210	5.3
16-108	31.22	18.11	0.97	18.7	77	916	1788	4750	16100	5.6
17-019	28.10	16.30	0.97	16.8	51	1080	1486	5020	15000	5.6
17-039	28.78	16.69	1.01	16.5	93	1300	1800	6530	21000	6.5
17-099	31.47	18.26	0.91	20.1	137	500	800	3030	3400	5.3
18-005	34.22	19.85	1.21	16.4	100	340	4810	3330	1910	5.6
20-048	35.98	20.87	1.40	14.9	68	238	7200	2250	550	5.0

(Continued)

Table 9 .-(Continued) Sample location and chemical properties of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Organic Matter %	Organic C %	Organic N %	C/N Ratio	P	K	Ca	Mg	Na	pH
					Extractable[1/] elements					
					ppm					
				Peaty Mucks (Continued)						
21-019	29.97	17.38	1.16	15.0	93	1310	2098	4030	24550	5.1
24-108	27.84	16.15	1.00	16.2	160	982	2000	3990	16450	5.2
24-128	33.50	19.43	1.55	12.5	54	510	6010	4570	14100	5.7
25-059	37.67	21.85	1.28	17.1	98	2480	3440	6700	39250	6.2
26-072	29.27	16.98	0.91	18.7	156	1042	624	4420	21200	6.3
26-098	37.91	21.99	1.25	17.6	137	1054	1562	4070	16250	4.9
28-108	34.12	19.79	0.78	25.4	181	1450	384	4360	21500	5.1
29-079	32.50	18.85	1.04	18.1	110	2430	3380	7020	43000	6.0
29-123	27.65	16.04	1.14	14.1	108	396	4560	2070	5470	5.2
29-129	31.96	18.54	1.10	16.9	30	242	4600	2040	3080	5.2
29-139	39.01	22.63	1.53	14.8	46	376	2570	3000	9450	4.8
29-149	28.36	16.45	0.95	17.3	15	178	4000	1350	1100	5.1
30-028	33.77	19.59	1.28	15.3	107	2000	3330	7720	36000	6.2
31-078	28.39	16.47	0.76	21.7	132	1600	1754	3890	18350	4.9
31-118	27.36	15.87	0.95	16.7	87	948	1162	2770	10500	5.0
32-078	30.70	17.81	0.87	20.5	156	1094	588	4100	17950	5.9
32-138	42.08	24.41	1.40	17.4	71	1092	3770	4950	23650	4.1
32-339	40.17	23.30	1.48	15.7	93	882	1960	4710	16350	5.2
33-078	40.86	23.70	1.78	13.3	76	1500	1060	7570	33000	6.2
33-149	28.12	16.31	1.32	12.4	122	1645	1342	4865	19000	5.5
33-152	35.26	20.45	1.15	17.8	117	1700	1778	6050	33000	5.7
33-159	34.61	20.08	0.98	20.5	151	1120	1312	4395	17000	5.6
33-179	33.77	19.59	1.68	11.7	102	1020	1040	6180	19000	5.5
33-207	29.32	17.01	1.15	14.8	107	1830	1816	5800	32000	6.3
33-214	28.63	16.61	0.84	19.8	181	1600	1622	5020	21000	6.5
33-263	32.18	18.67	1.05	17.8	78	1250	1248	4805	23000	5.5
33-273	35.20	20.42	1.13	18.1	122	1600	1528	5140	27000	6.1
34-298	34.43	19.97	0.90	22.2	108	1024	1110	4450	18050	5.7
35-041	32.60	18.91	1.02	18.5	139	1360	3070	4370	18250	5.1
35-045	38.88	22.55	1.30	17.3	156	1500	1296	4280	19250	4.7
35-209	34.57	20.05	1.17	17.1	171	1940	1740	5920	29150	6.0
35-229	41.31	23.96	1.38	17.4	156	1450	1578	5080	20850	4.8
35-238	31.15	18.07	1.11	16.3	120	1112	1722	4620	17200	5.4
					Mucky Peats					
2-068	69.19	40.14	2.20	18.2	15	1942	8230	10860	21300	5.5
2-118	52.05	30.19	1.49	20.3	63	904	5600	9060	21550	5.9
2-128	38.16	22.13	1.34	16.5	44	562	2820	4940	11750	5.3
4-045	40.74	23.63	1.23	19.2	100	1760	1880	5490	28750	6.2
10-068	55.40	32.13	1.89	17.0	29	360	6000	3450	6500	5.5
11-109	80.20	46.52	2.89	16.1	20	78	4420	2430	930	5.1
13-059	49.53	28.73	1.77	16.2	74	346	3960	5060	6600	5.0
13-079	78.18	45.35	2.45	18.5	37	234	7400	7920	6850	5.1
14-028	51.81	30.05	1.83	16.4	44	714	2920	5720	10650	5.1
14-038	42.91	24.89	1.55	16.1	54	996	2920	7960	22700	5.8
16-028	45.12	26.17	1.77	14.8	59	770	3906	5500	9950	5.4
16-118	66.70	38.69	2.13	18.2	29	900	6480	12400	25400	5.9
17-139	74.82	43.40	2.63	16.5	30	580	9500	8250	24000	5.9
19-078	41.82	24.26	1.52	16.0	81	266	5800	2850	2150	5.3
22-081	48.86	28.34	1.17	24.2	59	730	5600	7220	12600	5.8
23-079	56.00	32.38	1.96	16.5	112	920	2100	4200	10000	5.8
23-089	61.44	35.64	2.00	17.8	54	300	1160	3350	4000	5.0
23-108	53.99	31.68	1.94	16.3	63	220	4900	1825	1200	5.7
23-138	78.17	45.34	2.90	15.6	66	160	6500	1385	1800	5.9
24-118	66.67	38.67	2.32	16.7	51	820	5000	6540	20850	5.1
25-079	43.26	25.09	1.40	17.9	127	1052	1610	4010	13900	5.2
25-119	79.13	45.90	2.50	18.4	48	706	5240	6400	19400	5.5
25-169	72.93	42.30	2.64	16.0	37	194	9180	2520	2750	5.3
25-209	59.70	34.63	3.35	10.3	23	238	5310	1180	680	4.7

(Continued)

Table 9 .-(Continued) Sample location and chemical properties of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Organic Matter %	Organic C %	Organic N %	C/N Ratio	Extractable[1/] elements P	K	Ca	Mg	Na	pH
					ppm					
Mucky Peats (Continued)										
26-264	51.98	30.15	1.80	16.8	51	104	8820	1350	430	5.3
27-068	45.01	26.11	1.63	16.0	134	2260	4230	7360	36850	5.6
28-158	80.42	46.65	2.95	15.8	63	724	7970	6480	20600	4.6
28-238	68.27	39.60	2.51	15.8	54	130	2730	1970	2200	4.5
29-088	57.48	33.34	1.87	17.8	89	2100	5250	7960	42100	5.5
29-109	63.89	37.06	2.57	14.4	76	2100	5260	7320	42700	5.4
29-329	69.67	40.41	2.64	15.3	41	250	2530	3340	10300	4.9
30-048	62.39	36.19	2.07	17.5	59	2600	4750	10440	56800	5.9
30-058	53.10	30.80	2.14	14.4	49	2600	6180	12430	48000	6.4
30-098	42.21	24.48	1.39	17.6	73	1950	3160	6230	28000	5.7
30-118	77.25	44.81	2.15	20.8	83	1200	5100	9270	32000	6.0
30-178	48.66	28.23	1.79	15.8	76	1000	3810	5390	24000	4.4
30-202	52.38	30.38	1.93	15.7	59	740	2400	5670	17000	5.9
30-253	52.34	33.26	2.11	15.8	44	280	4500	3980	15000	5.6
31-108	40.88	23.71	1.15	20.6	108	1760	1870	4480	20700	5.0
31-128	69.60	40.37	2.23	18.1	93	1500	4160	9380	40600	6.1
31-188	74.17	43.02	2.41	17.9	64	220	4920	2810	11650	5.2
32-108	64.68	37.52	2.47	15.2	220	1100	1750	6100	25700	5.1
32-128	57.86	33.56	1.72	19.5	78	1066	3880	6180	24500	4.4
32-158	49.20	28.54	2.66	10.7	142	2260	5360	2990	35300	5.2
32-168	44.86	26.02	1.39	18.7	89	1046	4150	6100	20900	4.0
32-228	42.01	24.37	1.19	20.5	151	1002	1922	4030	11450	4.4
33-169	42.24	24.50	1.51	16.2	127	1870	1758	5700	25000	5.4
34-038	48.88	28.35	1.82	15.6	129	1330	4370	6860	31500	6.3
34-308	85.72	49.72	1.55	32.1	59	1040	3310	4980	18550	3.7
35-069	59.86	34.72	2.53	13.7	156	1068	3090	6440	18600	5.9
35-259	46.63	27.05	1.35	20.0	85	1450	1452	4800	20450	4.9
35-269	48.96	28.40	0.92	30.9	105	1340	1482	4490	20700	5.6
36-108	58.44	33.90	2.83	12.0	224	704	5170	3480	26150	6.1
36-118	55.10	31.96	1.89	16.9	181	1870	4340	7720	40200	5.4
36-138	46.91	27.21	1.73	15.7	85	1830	3510	6520	26450	5.4
Peats										
6-048	61.60	35.73	1.48	24.1	44	878	3804	8140	16500	5.5
7-058	64.08	37.17	2.08	17.9	16	230	4230	5460	4090	5.4
7-068	71.20	41.30	2.35	17.6	16	250	5400	6380	7200	5.4
9-059	52.50	30.45	1.35	22.6	44	530	5000	7720	11300	5.3
11-098	84.68	49.12	3.23	15.2	43	188	3904	2180	810	5.0
16-038	55.60	32.25	1.65	19.5	20	1440	5800	10840	28500	5.8
16-128	82.75	48.00	2.34	20.5	30	394	11270	9980	10550	5.5
17-021	57.25	33.21	1.88	17.7	54	1320	1734	5515	18000	4.8
19-058	87.49	50.75	1.80	28.2	29	194	5400	4360	1850	4.5
19-068	54.64	31.75	1.69	18.8	49	174	7800	2380	920	5.0
22-098	81.41	47.22	2.93	16.1	44	164	6600	3040	1710	5.2
22-108	77.49	44.95	2.53	17.8	39	204	11330	3370	1770	5.2
22-118	78.55	45.56	2.57	17.7	30	110	8400	2370	1450	5.2
23-098	82.03	47.58	2.24	21.2	54	440	3700	2435	7000	5.5
23-118	72.73	41.97	2.41	17.4	59	300	6800	1975	1300	5.4
23-129	75.29	43.67	1.88	23.2	66	280	4600	1020	900	6.0
24-148	85.32	49.49	2.65	18.7	30	232	7400	1880	3620	5.2
24-158	88.77	51.49	2.72	18.9	24	136	7400	2100	2540	5.2
24-168	84.91	49.25	2.90	17.0	54	198	7600	1380	930	5.2
24-178	77.94	45.21	2.38	19.0	41	102	8400	1790	900	5.2
24-188	79.61	46.18	3.16	14.6	73	420	9200	1670	1160	5.0
25-089	64.22	37.25	2.05	18.2	54	1220	4500	7300	29250	5.5
25-099	70.43	40.85	2.51	16.3	205	914	5990	6240	21600	4.9
25-109	73.68	42.74	2.45	17.4	37	868	4440	6240	20850	4.0
25-139	77.41	44.90	2.63	17.1	30	176	4760	2200	4780	5.1
25-159	86.99	50.46	2.86	17.6	39	98	5410	1090	1330	5.0

(Continued)

Table 9 .-(Continued) Sample location and chemical properties of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Organic Matter %	Organic C %	Organic N %	C/N Ratio	Extractable[1] elements P	K	Ca	Mg	Na	pH
					ppm	ppm	ppm	ppm	ppm	
				Peats (Continued)						
26-148	80.82	46.88	3.12	15.0	34	198	3020	4250	13600	4.6
26-154	81.22	47.11	2.84	16.6	137	568	6040	3810	9850	4.3
27-089	86.27	50.04	3.09	16.2	44	210	7620	2970	5900	5.0
27-134	53.03	30.76	2.02	15.2	40	156	5560	1360	480	4.8
27-189	79.46	46.09	2.55	18.1	41	162	6580	1330	4050	5.3
27-219	80.37	46.62	2.24	20.8	34	130	3660	580	576	4.9
27-229	69.32	40.21	2.21	18.2	54	212	5330	1090	1150	5.1
28-138	76.75	44.52	2.97	15.0	63	1070	5540	6020	20250	5.3
28-168	65.70	38.11	2.73	14.0	79	398	5420	2670	4700	5.4
28-218	84.20	48.84	2.78	17.6	132	191	3220	1700	5040	4.9
28-248	84.91	49.25	2.61	18.9	61	260	4930	1760	6190	4.4
29-159	66.63	38.65	1.71	22.6	183	420	5630	3070	7410	4.1
29-179	82.77	48.01	2.77	17.3	56	610	5270	4500	18950	5.5
29-199	89.03	51.64	3.12	16.6	71	260	6580	2340	6100	5.4
29-249	76.60	44.43	2.37	18.7	89	442	4850	2000	12900	5.1
29-259	88.23	51.18	2.50	20.5	49	270	5120	1580	5500	5.0
29-279	79.68	46.22	2.54	18.2	68	212	6850	990	1330	5.4
29-291	76.30	44.26	2.54	17.4	112	204	7640	1560	2370	5.1
29-339	65.43	37.95	2.26	16.8	55	750	4460	4970	18150	5.0
30-078	50.90	29.52	1.79	16.5	71	1400	4130	7530	33000	6.4
30-088	53.60	31.09	1.95	15.9	56	2150	4540	7350	30000	5.7
30-108	69.73	40.45	2.13	19.0	49	1650	4840	7100	36000	5.3
30-128	72.15	41.85	2.41	17.4	49	1100	2500	6870	24000	5.6
30-165	66.17	38.38	1.06	36.2	142	820	1760	4195	10000	6.2
30-175	68.74	39.87	2.44	16.3	54	1160	3800	6970	26000	5.9
30-208	73.34	42.54	2.76	15.4	44	680	5400	5300	22000	5.7
30-218	69.53	40.33	2.87	14.1	68	500	5600	5365	17000	5.9
30-258	74.49	43.21	2.67	16.2	71	220	5300	2920	7000	5.6
30-262	53.61	31.10	1.85	16.8	78	260	4800	3175	9000	5.5
30-268	69.01	40.03	2.62	15.3	49	180	4000	2400	8000	4.9
30-448	63.54	36.36	1.74	20.9	39	700	1700	3920	11000	4.9
31-158	69.20	40.14	3.10	13.0	67	942	5710	4970	23750	5.1
31-168	79.20	45.94	2.75	16.7	45	450	5450	3200	18100	5.3
31-178	50.29	29.17	2.64	11.0	93	436	3880	2940	11650	5.1
32-098	58.96	34.20	1.77	19.3	64	1700	3830	6240	26600	5.3
32-178	69.03	40.04	1.95	20.5	66	658	5080	4720	16800	3.8
33-059	50.86	29.50	1.84	16.0	88	496	4460	8620	43000	6.7
34-048	49.13	28.50	1.48	19.3	146	1470	2480	6520	27950	6.2
35-249	67.22	38.99	1.60	24.4	81	1132	1132	6180	29250	5.6
36-128	72.75	42.20	1.33	31.7	112	1500	1576	4440	24200	5.1
36-148	66.44	38.50	0.88	43.8	220	720	2450	5480	27450	6.5

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[1] Phosphorus was extracted with a solution of 0.10 N HCl containing 0.03 N ammonium fluoride. A soil-to-solution ratio of 1:20 was used. K, Ca, Mg, and Na was extracted with a 0.1 N HCl solution using a soil-to-solution ratio of 1:20.

Table 10.-Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

MINERAL SOIL MATERIALS

Sample Location	Type of Marsh1/	Water-soluble Cations and Anions							Total Water-soluble Salts
		K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	
		ppm							%
					Sandy Clays				
3-078	Fresh Water	70	110	90	925	1500	654	104	0.35
3-088	Fresh Water	46	186	80	1632	2000	540	704	0.52
5-149	Brackish	116	190	550	2945	8700	1194	44	1.37
8-033	Brackish	78	186	160	2620	3300	930	962	0.82
32-268	(Levee)	272	356	760	4960	7400	5010	607	1.94
					Silty Clays				
26-061	Salt Water	416	1850	1220	9075	10400	6750	1627	3.13
35-019	Salt Water	428	592	950	6020	11200	5070	473	2.47
36-078	(Bay)	220	450	770	2450	3200	5925	459	1.35
38-018	(Spoil Deposit)	140	864	280	650	1500	1005	222	0.47
38-041	(Spoil Deposit)	120	236	70	530	729	340	651	0.27
38-103	(Pond)	22	644	500	1350	1500	765	44	0.48
					Clays				
1-008	Brackish	188	250	553	5680	8499	675	828	1.67
1-018	Fresh Water	70	370	110	1210	1600	390	1173	0.49
1-028	Fresh Water	115	620	50	1270	1600	404	1083	0.50
2-098	Brackish	115	320	280	2350	4000	1359	30	0.84
2-108	Fresh Water	90	195	50	450	700	735	252	0.25
3-018	Brackish	160	430	160	2170	3000	1827	710	0.85
3-108	Fresh Water	55	104	30	570	1000	729	533	0.30
4-018	Brackish	240	590	350	4110	4000	690	1835	1.18
5-109	Fresh Water	52	136	120	1560	2500	990	1169	0.65
5-119	Fresh Water	24	92	40	120	240	339	237	0.11
6-008	Brackish	126	218	300	3000	4700	1005	1406	1.08
6-028	Fresh Water	170	112	120	1070	1500	1032	275	0.43
7-008	Salt Water	274	280	570	6200	10200	1824	1657	2.10
7-018	Fresh Water	70	112	40	520	700	570	681	0.27
8-009	Brackish	294	290	390	5580	9700	1395	533	1.82
9-009	Salt Water	326	370	600	5880	12200	1320	1361	2.21
10-038	Fresh Water	115	265	210	1580	1000	969	1539	0.57
11-129	Fresh Water	55	265	20	112	600	345	607	0.20
12-008	Salt Water	230	400	890	6600	10300	4185	1361	2.40
12-108	Fresh Water	70	200	10	124	500	56	243	0.12
13-019	Fresh Water	170	226	150	1720	2100	885	389	0.56
14-008	Brackish	80	410	80	1120	1900	1254	843	0.57
15-009	Salt Water	322	475	530	6440	11200	2370	828	2.22
15-089	(Pond)	64	325	90	1110	1500	1350	178	0.46
22-004.5	Brackish	336	320	390	5110	8700	2235	888	1.80
22-008	Salt Water	386	508	1230	9750	16600	5475	326	3.43
22-096	Fresh Water	24	200	40	296	700	249	1006	0.25
23-004	Brackish	340	265	640	4472	10200	2364	473	1.88
23-019	Brackish	389	295	450	3936	9200	1134	1479	1.69
24-058	Salt Water	326	320	500	5910	10200	1995	1746	2.10
25-021.5	Salt Water	310	325	490	6190	10400	1860	621	2.02
26-051	Salt Water	550	530	960	7400	13100	5385	222	2.81
31-058	Brackish	306	800	800	4870	7700	4440	207	1.91
32-243	(Bayou)	352	140	160	2800	2500	2490	755	0.92
33-028	(Bay)	300	620	450	4010	6000	3780	207	1.54
33-133	Brackish	229	250	470	3870	6000	3054	30	1.39
34-028	Brackish	284	236	470	5340	8900	2256	1125	1.86
34-085	Brackish	172	194	280	4240	6900	1380	710	1.39
34-138	Salt Water	304	364	720	6030	9900	3420	988	2.17
34-158	Salt Water	358	694	880	5110	9400	4545	1420	2.24
35-055	Salt Water	480	438	970	7280	12400	5010	577	2.72

(Continued)

Table 10.- (Continued) Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

MINERAL SOIL MATERIALS

		Water-soluble Cations and Anions							Total Water-soluble Salts
Sample Location	Type of Marsh[1/]	K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	
		ppm							%
					Clays (Continued)				
35-074	Salt Water	500	436	1460	16500	27800	3360	799	5.09
35-148	Salt Water	364	568	930	5860	11700	4110	296	2.38
35-189	(Spoil Deposit)	184	390	450	3720	4978	4275	355	1.44
36-002	(Spoil Deposit)	110	86	100	2650	3700	930	1094	0.87
36-088	Brackish	178	500	480	2210	3200	3765	118	1.05
36-098	Brackish	216	878	810	4330	7900	4779	982	1.99
36-298	Salt Water	316	292	700	7040	9400	1830	1094	2.07
36-418	Salt Water	320	312	800	7740	13357	2520	355	2.54
37-058	Fresh Water	120	580	180	360	500	510	237	0.25
37-107	Brackish	96	610	310	1250	1828	1130	74	0.53
38-017	Fresh Water	140	475	90	530	850	260	311	0.27
38-064	(Bayou bank)	110	500	60	460	971	270	636	0.30
38-072	Fresh Water	140	528	190	390	607	770	340	0.30
38-081	Fresh Water	120	610	80	300	600	385	533	0.26
38-091	(Bayou bank)	155	670	170	610	1000	1275	533	0.44
39-032	Fresh Water	195	580	250	1190	1699	800	237	0.50
					Mucky Clays				
1-038	Brackish	180	275	490	4180	8900	2724	740	1.75
2-058	Brackish	220	1500	370	4700	8700	2175	414	1.81
3-008	Brackish	273	460	480	3960	5200	3465	5829	1.97
3-028	Brackish	115	270	160	2052	3200	1233	710	0.77
4-015	Brackish	590	615	1600	10700	19600	6000	314	3.94
4-028	Brackish	400	410	860	7450	14000	1923	562	2.50
5-019	Brackish	170	136	180	2130	2200	2334	2278	0.94
7-048	Fresh Water	80	112	50	730	1000	729	414	0.31
8-019	Brackish	78	154	110	1820	2600	1320	222	0.63
10-108	Fresh Water	115	200	70	490	500	579	237	0.22
13-029	(Pond)	140	206	120	1350	2100	533	207	0.47
27-006	Salt Water	480	450	1160	12100	19800	3654	44	3.77
27-049	Salt Water	575	710	1475	11250	17700	6819	111	3.86
28-063	Salt Water	760	910	1470	13750	21300	7305	473	4.60
29-069	Salt Water	550	580	1160	11550	16100	3495	1539	3.50
30-198	(Spoil-levee)	139	820	780	3090	5200	5964	473	1.65
32-278	Brackish	220	214	390	3770	6200	2790	74	1.37
34-068	Brackish	256	302	570	6940	11400	2115	1065	2.26
36-288	(Bay)	368	390	820	6660	11700	3585	148	2.37
37-258	Salt Water	630	580	1270	10750	16999	3075	163	3.35
					Peaty Clays				
1-014	Brackish	180	275	440	3260	5200	2766	343	1.25
2-008	Brackish	115	320	210	2060	3200	1359	2131	0.94
4-008	Brackish	315	410	550	6100	9400	1290	2130	2.02
4-047	Fresh Water	115	230	100	1040	1500	540	2944	0.65
4-078	Brackish	273	380	530	4280	7200	2394	503	1.56
7-028	Fresh Water	82	144	160	1250	1500	365	497	0.40
8-039	Fresh Water	46	206	90	1100	1500	582	1539	0.51
9-019	Brackish	430	460	1060	2399	14900	5589	59	2.49
9-039	Fresh Water	36	206	150	1540	1760	650	150	0.46
10-088	Fresh Water	90	320	140	940	1100	969	740	0.43
11-028	Brackish	278	290	670	4860	8100	3015	1021	1.82
11-048	Fresh Water	110	322	320	1540	2064	225	337	0.49
12-017	Brackish	110	238	270	2720	3700	2010	1184	1.02
13-009	Brackish	125	194	100	1440	1700	1596	888	0.60
13-049	Fresh Water	95	350	250	1770	3200	1080	947	0.77

(Continued)

Table 10.- (Continued) Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

MINERAL SOIL MATERIALS

Sample Location	Type of Marsh[1]	Water-soluble Cations and Anions							Total Water-soluble Salts
		K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	
		ppm							%
		Peaty Clays (Continued)							
21-079	Fresh Water	125	176	180	930	1700	1155	1554	0.58
23-029	Brackish	340	350	630	3759	8600	2397	1183	1.73
25-069	Salt Water	895	2200	2310	14800	24800	11664	2234	5.89
26-034	Salt Water	630	658	1710	16150	25800	5640	473	5.11
27-039	Salt Water	888	1625	2475	17563	27900	10827	1461	6.27
27-099	Fresh Water	80	410	110	195	1000	252	1841	0.39
28-078	Salt Water	810	1350	1910	13400	24800	8499	2027	5.28
28-118	Salt Water	1000	1620	2240	17900	28500	8814	2621	6.27
30-166	Brackish	160	225	400	3910	7940	1320	59	1.40
31-038	Salt Water	458	1180	1250	10000	14900	5805	1642	3.52
32-248	Brackish	458	462	1240	7550	13400	6810	178	3.01
33-039	Salt Water	602	820	1435	11750	20300	5310	74	4.03
33-126	Brackish	405	670	1180	10600	18800	3525	790	3.60
33-134	Brackish	273	420	570	5300	9900	2520	947	1.99
33-254	Brackish	430	610	1450	10250	18400	5115	207	3.65
33-255	Brackish	250	390	740	5050	9200	3675	178	1.95
33-261	Brackish	250	430	730	5950	10900	2559	414	2.12
33-269	Brackish	389	580	1280	11350	14400	6564	266	3.48
34-097	Salt Water	454	828	1300	7840	12200	6885	592	3.01
34-168	Brackish	294	364	880	4890	9200	3930	89	1.96
34-198	Brackish	422	438	1240	7310	13900	4905	83	2.83
35-178	Salt Water	486	490	1200	11200	17900	4335	414	3.60
35-332	(Bayou bank)	210	330	660	3570	5221	501	325	1.08
36-351	Brackish	436	540	980	10150	16400	3075	1480	3.31
37-087	Fresh Water	240	525	430	1750	2307	3600	148	0.90
37-095	Fresh Water	160	420	190	1100	1821	510	30	0.42
37-319	Salt Water	486	424	1220	11900	17900	4125	148	3.62
37-359	Salt Water	630	725	1380	10150	19600	4080	118	3.67

ORGANIC SOIL MATERIALS

Sample Location	Type of Marsh[1]	K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	Total Water-soluble Salts
		Clayey Mucks							
2-048	(Pond)	320	670	890	7650	13100	5475	651	2.88
2-078	Brackish	250	370	810	6550	11400	3270	237	2.29
4-058	Brackish	460	380	920	9100	15600	3879	1035	3.14
4-068	(Pond)	340	440	720	6800	11700	2655	385	2.30
9-049	Fresh Water	110	228	110	1420	2000	1059	636	0.56
9-069	Fresh Water	168	270	170	1210	1400	1989	805	0.60
10-028	Brackish	273	460	880	4559	10400	3324	325	2.02
26-078	Salt Water	490	554	970	6570	11900	4980	710	2.62
26-234	Fresh Water	55	325	110	132	729	310	503	0.22
35-198	Salt Water	500	1140	1650	12600	19800	6885	1835	4.44
		Silty Peats							
34-331	Fresh Water	240	364	850	2270	4200	4890	59	1.29
36-328	Salt Water	1180	1615	4340	30950	55100	11949	237	10.54
		Clayey Peats							
1-043	Brackish	630	610	2197	15995	26105	2265	540	4.83
2-138	Fresh Water	160	640	790	2970	8400	3294	118	1.64
5-029	Brackish	750	725	2479	19563	36900	6609	1220	6.82
7-078	Fresh Water	70	112	60	277	700	504	148	0.19

(Continued)

Table 10.- (Continued) Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Type of Marsh[1]	Water-soluble Cations and Anions							Total Water-soluble Salts
		K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	
		ppm							%
				Clayey Peats (Continued)					
8-049	Brackish	116	320	520	2383	5700	2724	544	1.23
8-059	Brackish	110	218	160	1630	2500	1212	710	0.65
10-005	Brackish	500	770	1710	12900	22100	4365	947	4.33
10-014	Brackish	405	495	1770	11300	20000	6000	888	4.09
10-018	Brackish	300	370	750	5120	8100	3225	178	1.80
10-098	Fresh Water	115	270	140	1130	1600	1059	533	0.48
11-008	Brackish	520	668	2390	16650	29800	8340	1154	5.95
11-038	Fresh Water	50	206	180	1160	1200	1380	1746	0.60
13-039	Fresh Water	110	226	180	1700	3200	930	473	0.68
14-018	Brackish	168	410	430	2140	2700	4050	340	1.02
15-079	Brackish	390	620	1150	7160	12900	5490	385	2.81
16-008	Brackish	140	440	130	1980	3000	1668	473	0.78
16-018	Brackish	300	380	660	4370	7400	4725	325	1.82
17-004	Brackish	405	835	1980	12050	48400	7125	947	7.17
17-009	Brackish	430	700	1780	11050	20800	8625	947	4.43
18-012	Fresh Water	80	144	655	600	1200	840	533	0.41
19-048	Brackish	140	475	290	2500	4700	2235	1095	1.14
21-009	Brackish	390	440	910	5870	10700	5115	1480	2.49
21-099	Fresh Water	110	340	160	420	1000	1080	2234	0.53
22-018	Brackish	840	1600	3250	20100	36200	11364	178	7.35
22-068	Fresh Water	140	330	380	1570	2700	3336	858	0.93
23-039	Brackish	620	975	2573	13092	22800	6810	1183	4.81
23-049	Brackish	579	640	1570	9276	16900	9000	88	3.81
24-048	Salt Water	660	978	2060	15950	28500	7245	917	5.63
24-098	Salt Water	500	1700	1950	11400	20500	7884	1746	4.57
26-087	Brackish	448	1000	1510	7390	11700	8880	148	3.11
26-118	Brackish	448	978	2040	6340	9700	12300	562	3.24
28-098	Salt Water	496	682	1050	8455	40900	3765	1953	5.73
28-207	Fresh Water	46	450	150	347	1200	651	2663	0.55
29-239	Fresh Water	72	378	480	2250	4000	3480	755	1.14
30-018	Brackish	523	600	2060	14450	25500	7110	----	5.02
31-048	Salt Water	760	1730	2590	17900	20500	11340	976	5.58
31-098	Salt Water	810	1350	2990	20300	28200	12600	592	6.68
32-238	Brackish	496	392	1510	6630	10400	8550	148	2.81
33-049	Salt Water	710	940	2200	16650	31200	6600	89	5.84
33-126.5	Brackish	500	640	1530	12800	23300	4536	89	4.34
33-129	Brackish	500	670	1410	10900	18600	4980	89	3.71
33-273	Brackish	486	838	1338	9875	18300	5214	148	3.62
34-018	Salt Water	660	966	2390	15300	25500	8850	385	5.41
34-118	Salt Water	580	748	2110	14300	23600	7560	118	4.90
34-148	Salt Water	630	774	2110	14650	23600	7500	124	4.94
34-288	Brackish	390	528	1410	6640	12600	6945	237	2.88
35-063	Salt Water	680	904	1900	16050	25800	6540	1213	5.31
				Mucks					
2-038	Brackish	250	475	1040	4950	7900	6564	148	2.13
3-038	Brackish	229	360	940	5750	10400	4260	1065	2.30
9-029	Fresh Water	80	225	147	1420	2000	900	103	0.49
10-048	Fresh Water	180	870	680	3750	5700	2718	1065	1.50
10-058	Fresh Water	273	615	1500	6400	11200	4440	445	2.49
12-048	Fresh Water	86	238	240	1240	1500	2190	118	0.56
22-133	Fresh Water	208	360	134	1325	2070	1503	395	0.60
32-148	Brackish	580	1240	2830	13100	20300	13200	400	5.17

(Continued)

Table 10.- (Continued) Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Type of Marsh[1/]	Water-soluble Cations and Anions							Total Water-soluble Salts
		K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	
		ppm							%
					Peaty Mucks				
2-088	Brackish	573	875	2013	14813	18500	7950	1302	4.60
6-038	Brackish	480	654	2120	14950	28300	5925	651	5.31
6-058	Brackish	125	263	900	3138	5300	4125	610	1.45
9-129	Fresh Water	138	243	300	480	900	843	1868	0.48
10-008	Brackish	602	870	2380	17000	30700	3774	2268	5.76
11-018	Brackish	498	460	1370	10000	17700	4350	1214	3.56
11-088	Fresh Water	100	273	138	981	2200	1239	499	0.54
13-069	Brackish	178	438	438	2650	4800	1818	1701	1.20
16-108	Brackish	575	925	2138	13760	18900	8439	1050	4.58
17-019	Brackish	389	775	2031	10800	19600	7875	355	4.18
17-039	Brackish	500	915	1847	16500	31900	7500	1243	6.04
17-099	Brackish	210	330	760	2300	3000	4605	444	1.16
18-005	(Pond)	103	475	588	1850	2500	4725	111	1.04
20-048	Fresh Water	138	755	425	588	900	5214	148	0.82
21-019	Brackish	850	895	3500	18938	26800	11814	288	6.31
24-108	(Pond)	600	978	2780	13700	23200	11664	59	5.30
24-128	Brackish	352	170	1950	12700	23300	3138	1627	4.32
25-059	Salt Water	174	1435	5160	35600	70900	11964	2396	12.76
26-072	Salt Water	625	958	2425	18000	33500	6318	1294	6.31
26-098	(Pond)	613	868	2213	14000	23600	8904	1136	5.13
28-108	Salt Water	1080	1400	2880	18650	29800	12300	89	6.62
29-079	Salt Water	1513	1475	4375	38438	55900	1335	1110	10.41
29-123	Fresh Water	148	1460	830	3900	9200	3480	311	1.93
29-129	Fresh Water	165	490	310	2220	4500	1644	1657	1.10
29-139	Fresh Water	178	1020	1280	6650	12900	5316	326	2.77
29-149	Fresh Water	150	243	100	938	1500	639	503	0.41
30-028	Salt Water	1152	915	3710	28400	27500	10650	118	7.24
31-078	Salt Water	650	1063	2350	15788	24800	9543	1590	5.58
31-118	Fresh Water	348	474	1040	7820	12900	4545	163	2.73
32-078	Brackish	740	1344	2260	13865	28500	6750	178	5.36
32-138	Brackish	710	1560	3910	20450	33500	16350	148	7.66
32-339	Brackish	520	840	2570	14250	23800	9249	148	5.14
33-078	(Pond)	389	475	610	3660	6400	4125	30	1.57
33-149	Brackish	788	938	2450	17875	31900	8250	148	6.23
33-152	Brackish	724	875	2300	18313	32500	5214	684	6.06
33-159	Brackish	573	963	1838	14188	25700	2493	1054	4.68
33-179	Brackish	389	820	1600	9550	16600	6489	178	3.56
33-207	(Pond)	888	1044	2788	23062	39800	6468	518	7.46
33-214	Brackish	753	875	2263	19125	35300	5025	795	6.41
33-263	Brackish	724	1225	2675	18563	33200	8673	333	6.54
33-273	Brackish	486	838	1338	14169	18300	5214	148	4.05
34-298	Brackish	600	725	2263	16688	27900	5964	93	5.42
35-041	Salt Water	750	935	2563	15975	25700	3850	129	4.99
35-045	Brackish	790	1000	2680	16150	25300	10764	1036	5.77
35-209	Brackish	920	890	2960	22700	37900	7425	414	7.32
35-229	Brackish	600	920	2700	16350	26500	10410	118	5.76
35-238	Brackish	550	736	2070	14500	23300	7362	148	4.87
					Mucky Peats				
2-068	Brackish	725	1738	3838	12919	40000	15750	89	7.51
2-118	(Pond)	523	2300	2420	16400	31200	6555	355	5.98
2-128	(Pond)	286	913	1338	8750	9600	5154	222	2.63
4-045	Brackish	625	731	2083	24250	32200	3495	1094	6.45
10-068	Fresh Water	229	380	997	2691	6400	3732	607	1.50
11-109	Fresh Water	42	551	125	790	1500	2622	678	0.63
13-059	Fresh Water	210	656	875	3838	11200	4332	222	2.13

(Continued)

Table 10.- (Continued) Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Type of Marsh[1/]	Water-soluble Cations and Anions							Total Water-soluble Salts
		K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	
		ppm							%
		Mucky Peats (Continued)							
13-079	Fresh Water	103	625	823	3550	5700	5145	74	1.60
14-028	Brackish	460	680	1838	6900	12700	9489	740	3.28
14-038	Brackish	575	850	2525	16688	30900	8064	166	5.98
16-028	Brackish	455	590	1200	7200	12000	6492	185	2.81
16-118	Brackish	750	1531	4638	26125	53300	12609	370	9.93
17-139	Brackish	415	975	1990	12750	29500	2950	1450	5.00
19-078	Brackish	103	590	538	1475	2600	5682	89	1.11
22-081	Fresh Water	363	913	1663	7750	14600	7968	592	3.38
23-079	Brackish	480	1040	1012	6556	14300	7536	4054	3.50
23-089	Brackish	229	585	1480	3067	2200	8589	1420	1.76
23-108	Fresh Water	115	440	360	830	1400	1359	1692	0.62
23-138	(Pond)	140	440	150	810	1600	609	816	0.46
24-118	Brackish	625	2063	2988	15500	29400	11418	296	6.23
25-079	Brackish	710	990	2360	11650	20100	10089	207	4.61
25-119	Brackish	548	2063	2288	13625	26000	7218	148	5.19
25-169	Fresh Water	154	775	638	2673	5300	2907	518	1.30
25-209	Fresh Water	122	890	400	210	420	1255	1024	0.43
26-264	Fresh Water	88	438	88	363	862	175	1017	0.30
27-068	Brackish	99	1750	4463	34375	58000	11625	222	11.05
28-158	Fresh Water	719	3424	4542	22491	25300	14286	888	7.17
28-238	Fresh Water	126	1688	1025	1410	3700	9240	74	1.73
29-088	Brackish	1375	2300	4725	37823	62300	12468	5658	12.66
29-109	Brackish	1438	2500	4513	41438	67600	12468	74	13.00
29-329	Fresh Water	185	1625	1975	7775	13600	11214	777	3.72
30-048	Salt Water	1904	1563	5363	42125	77100	13407	2900	14.44
30-058	Salt Water	2238	1844	7088	56750	130500	14952	1146	21.45
30-098	Brackish	1085	1613	3713	28625	49000	10218	148	9.44
30-118	Brackish	1051	1219	2498	24063	46200	8907	666	8.46
30-178	Brackish	630	1438	3070	20350	36200	11025	71	7.28
30-202	Brackish	360	865	2060	13650	25900	6789	178	4.98
30-253	Fresh Water	174	800	1213	7688	14100	4182	1505	2.97
31-108	Brackish	790	1240	2890	20550	32500	9690	1065	6.87
31-128	Brackish	1250	1950	4775	39563	65700	8175	444	12.19
31-188	Fresh Water	178	1888	1488	9113	17000	7743	111	3.75
32-108	Brackish	788	1550	3150	20563	34400	10875	185	7.15
32-128	Brackish	580	1510	3360	19550	33000	12675	178	7.09
32-158	Brackish	1150	3500	4580	25450	43600	15489	314	9.41
32-168	Brackish	925	2163	4850	18425	28400	23007	947	7.87
32-228	Brackish	500	1070	2220	9200	13400	11814	207	3.84
33-169	Brackish	919	1550	3388	24563	41500	9891	148	8.20
34-038	Salt Water	1313	2025	3800	28938	48800	12150	3495	10.05
34-308	Brackish	688	1688	3838	16375	26300	20439	----	6.93
35-069	(Bay)	630	760	2030	14050	23800	6060	473	4.78
35-259	Brackish	825	1275	3600	20813	32500	13689	222	7.29
35-269	(Pond)	538	853	2425	15975	26300	8268	222	5.46
36-108	Brackish	390	1730	1470	17300	27000	5805	385	5.41
36-118	(Bay)	1150	2770	4540	33650	57000	14400	340	11.39
36-138	Brackish	580	1460	2940	18650	32000	10275	178	6.61
		Peats							
6-048	Brackish	480	743	2238	12125	21100	8193	177	4.51
7-058	Fresh Water	68	263	475	2300	4000	2043	629	0.98
7-068	Fresh Water	170	723	1500	3426	11200	6843	----	2.39
9-059	Brackish	270	663	1675	7175	11300	7827	666	2.96
11-098	Fresh Water	74	308	140	351	1300	999	129	0.33
16-038	Brackish	1113	1575	4880	29688	57000	13989	740	10.90

(Continued)

Table 10.- (Continued) Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Type of Marsh1/	Water-soluble Cations and Anions K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	Total Water-soluble Salts
		ppm							%
		Peats (Continued)							
16-128	Brackish	215	725	725	7725	13600	2514	1960	2.75
17-021	Brackish	500	800	2150	12220	22800	8139	1361	4.80
19-058	Fresh Water	119	252	175	735	2188	669	536	0.47
19-068	Fresh Water	63	952	543	945	1560	973	148	0.52
22-098	Fresh Water	158	623	184	1052	2480	490	641	0.56
22-108	Fresh Water	90	895	563	1225	2500	5520	1294	1.21
22-118	Fresh Water	53	438	173	800	1500	816	536	0.43
23-098	Fresh Water	382	891	656	4576	5300	1890	1627	1.53
23-118	Fresh Water	174	574	350	1188	1900	1095	1390	0.66
23-129	Fresh Water	222	752	317	1046	1000	969	1094	0.54
24-148	Fresh Water	151	508	350	3360	7150	1206	311	1.30
24-158	Fresh Water	117	327	255	2265	5000	849	623	0.94
24-168	Fresh Water	119	306	105	418	1500	810	578	0.38
24-178	Fresh Water	90	688	165	529	1900	810	1780	0.60
24-188	Fresh Water	156	656	250	1200	2200	1164	----	0.56
25-089	Brackish	1050	1581	5250	25125	48400	11625	407	9.34
25-099	Brackish	850	2569	4600	21937	48400	19500	222	9.81
25-109	Brackish	725	2813	3809	17563	38100	21093	----	8.41
25-139	Fresh Water	178	895	788	3988	5700	3120	2929	1.76
25-159	Fresh Water	53	323	150	1138	2479	1269	2911	0.83
26-148	Fresh Water	203	1950	2288	11313	20100	9693	222	4.58
26-154	Fresh Water	508	2163	2550	7225	14300	16218	259	4.32
27-089	Fresh Water	178	693	750	4613	9900	1464	703	1.83
27-134	Fresh Water	100	844	275	420	1000	2475	473	0.56
27-189	Fresh Water	108	775	350	3450	4400	1275	1775	1.21
27-219	Fresh Water	69	353	100	415	1650	705	----	0.34
27-229	Fresh Water	152	320	234	1033	2890	1149	104	0.59
28-138	Salt Water	1088	3300	3863	27500	49900	11418	222	9.73
28-168	Fresh Water	250	920	688	4313	8400	2568	666	1.78
28-218	Fresh Water	180	1234	902	4576	8270	6417	49	2.16
28-248	Fresh Water	182	1703	1253	4943	8680	9891	148	2.68
29-159	Fresh Water	244	2438	2038	6179	10700	15690	444	3.77
29-179	Fresh Water	459	1492	2038	17576	19400	4110	1302	4.64
29-199	Fresh Water	129	828	651	4643	10030	1974	788	1.90
29-249	Fresh Water	277	1703	1570	11222	7300	8310	858	3.12
29-259	Fresh Water	158	1214	802	4709	9100	5340	395	2.17
29-279	Fresh Water	59	376	200	1042	2610	384	96	0.48
29-291	Fresh Water	129	571	367	1887	4550	1770	444	0.97
29-339	Brackish	620	1688	3500	18125	29100	13014	873	6.69
30-078	Brackish	1032	915	3250	25350	23300	7875	385	6.21
30-088	Brackish	1115	1811	3800	27437	52100	9768	370	9.64
30-108	Brackish	1015	1750	4263	28688	53300	13032	259	10.23
30-128	Brackish	753	831	2488	17375	31900	6807	163	6.03
30-165	Brackish	389	500	1030	6400	11900	3885	710	2.48
30-175	Brackish	725	725	2275	3388	40800	5379	1246	5.45
30-208	Brackish	341	969	1850	14875	34000	3984	----	5.60
30-218	Fresh Water	286	906	1525	9663	19400	3939	1389	3.71
30-258	Fresh Water	174	800	1038	5413	10500	4725	703	2.33
30-262	Brackish	160	104	1170	5900	10900	5964	414	2.46
30-268	Fresh Water	225	1844	1375	6375	12100	8952	7	3.09
30-448	Fresh Water	375	688	1700	9313	17400	5157	370	3.50
31-158	Brackish	600	2025	3213	21688	35500	12114	222	7.54
31-168	Fresh Water	347	144	1536	12475	25600	4326	148	4.46
31-178	Brackish	330	137	1530	9885	16800	8529	111	3.73
32-098	Brackish	850	1208	2975	22225	35300	9114	93	7.18
32-178	Brackish	396	1620	2840	10550	14100	15489	503	4.55

(Continued)

Table 10.- (Continued) Sample location, type of marsh, water-soluble cations and anions and total water-soluble salts of soil materials in the Coastal Marshlands of Louisiana.

ORGANIC SOIL MATERIALS

Sample Location	Type of Marsh[1]	Water-soluble Cations and Anions							Total Water soluble Salts
		K^+	Ca^{++}	Mg^{++}	Na^+	Cl^-	$SO_4^=$	HCO_3^-	
		ppm							%
		Peats (Continued)							
33-059	Salt Water	1641	1800	3696	45125	81200	10623	592	14.47
34-048	(Pond)	1150	2363	3764	25563	41500	14025	2182	9.05
35-249	Brackish	680	774	2400	18300	31000	6060	326	5.95
36-128	Brackish	630	978	2610	18900	31700	8325	237	6.34
36-148	Salt Water	710	1070	2680	18850	31500	5865	1628	6.23

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[1] Field classification by A. W. Palmisano and R. H. Chabreck, Assistant Unit Leader, Louisiana Cooperative Wildlife Research Unit, Louisiana State University, and Associate Professor, School of Forestry and Wildlife Management, Louisiana State University, respectively.

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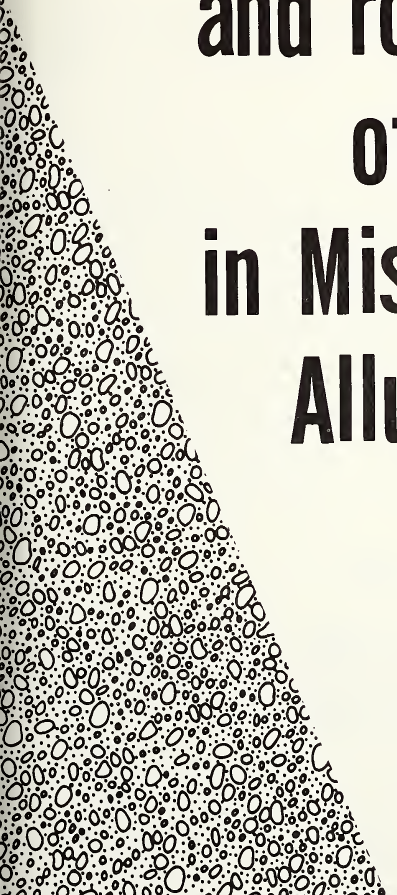
Soil oxygen content and root development of cotton in Mississippi River Alluvial soils



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Abstract

Measurements of soil oxygen in a 4-foot profile of Mississippi River Alluvial soils differing in texture and internal drainage showed marked differences in oxygen status throughout the growing season. The better drained, coarser textured soils (Bruin and Dundee) had high oxygen content at all depths in the profile during the entire season. The poorer drained soils (Mhoon and Tunica) were usually low in oxygen below the 1-foot depth during the first part of the growing season. As the season progressed, the soil dried out enough for oxygen to enter the profile. Even after the soils had become dry enough for oxygen to penetrate to the subsoil, heavy rainfall caused depletion of oxygen in the subsoil of the Mhoon and Tunica soils.

Soil oxygen content apparently governed root penetration and development in these soils. A high positive correlation existed between subsoil oxygen content during the first part of the growing season and the amount of roots that developed in the subsoil. Even though the oxygen status of the fine-textured, poorly drained soils improved in July and August, this improvement was not reflected in subsoil root development.

Soil Oxygen Content and Root Development of Cotton in Mississippi River Alluvial Soils[1]

W. H. Patrick, Jr., R. D. Delaune and R. M. Engler[2]

Introduction

The fine-textured, low-lying floodplain soils in the Mississippi River Valley are fertile in terms of plant nutrients but are frequently limited in their productivity, presumably as a result of restricted soil aeration caused by poor internal drainage. Although restricted oxygen supply is frequently cited as one of the major limiting factors in crop production on these soils, no experiments have been carried out to evaluate their oxygen status or to determine the effect of low oxygen content on root development and plant growth. The purpose of the study reported here was to measure the oxygen content of a number of Mississippi River Alluvial soils differing in texture and internal drainage and to determine if oxygen content in these soils was related to subsoil root development.

Review of Literature

Adequate soil oxygen is essential for normal root growth for most plants. Previous research has shown that decreasing the oxygen supply to the root system results in decreased respiratory activity, reduced water and nutrient absorption, and reduced rooting depth and growth of various plants.

Under good aeration conditions, the oxygen content in the soil approaches that of atmospheric air; under poor aeration conditions, the oxygen content is decreased. The optimum soil oxygen requirement for root development and plant growth varies greatly with species and age of plant (Leyton and Rousseau, 1958). Some species can apparently survive with only 1 or 2 percent oxygen, but an oxygen content greater than 10 percent is required for good growth of most plants (Kohnke, 1968; Kramer, 1969).

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[2] Professor and Associates, respectively, Department of Agronomy, Louisiana Agricultural Experiment Station, Baton Rouge.

Much of the information concerning the importance of soil oxygen to cotton growth is based on inference rather than quantitative data obtained from the field. It is generally accepted that changes in soil physical properties such as texture and especially soil moisture content result in changes in soil oxygen content (Russell, 1952). However, there is a surprising lack of data to prove these relationships.

Root growth and activity are generally restricted when the oxygen content in the soil is limited (Hopkins et al., 1950; Kramer, 1951; Patrick et al., 1969). Letey et al. (1962a, 1962b) reported that the roots of cotton, sunflower and beans ceased growing at low oxygen levels and that an oxygen content of less than 1 percent was detrimental during the early stages of growth. Patrick et al. (1969) found that oxygen content was a limiting factor for optimum root development of sugarcane, especially in the first part of the growing season in heavy-textured and poorly drained soils. Geisler (1967) showed that as the concentration of oxygen was reduced to very low levels, both root and top growth decreased.

Root elongation is one plant function that can be closely related to soil oxygen content. Stolzey et al. (1961) found that root elongation increased as the soil oxygen content increased to 21 percent. Hopkins and Patrick (1969) found that low oxygen content in the soil suppressed the penetration of roots into the soil. Huck (1970) investigated the effects of short-term fluctuations in soil oxygen and root elongation of cotton. He found that root elongation ceased completely within 2 or 3 minutes after all oxygen was purged from the system with nitrogen and that root elongation returned to normal shortly after 21 percent oxygen was reapplied to the system. This rapid response implied that oxygen is involved in cell expansion. Periods of no oxygen for longer than 30 minutes caused increasing taproot death until all roots were killed after 3 hours. Such short-term oxygen deficiency might occur in flooded soils or in soils with perched water tables caused by the presence of tillage pans.

Eavis et al. (1971) demonstrated the effect of longitudinal internal diffusion of oxygen on pea radicle elongation. When air was maintained at 21 percent oxygen around the shoot, sufficient oxygen diffused through the plant pathways for radicles in humidified nitrogen gas to elongate at a rate equal to 20 percent of that of the controls, where entire seedlings were maintained in 21 percent oxygen. When radicles were maintained in 21 percent oxygen, but the cotyledons in nitrogen, the radicle elongation was 50 percent of that of the controls. This would indicate that oxygen moves both up and down the root tissue.

Water uptake by plants is reduced by soil oxygen deficiency, directly through its effect on absorption and indirectly by reducing root growth. Childers and White (1942) observed that the capability for water absorption was reduced when plants were grown under flooded soil conditions. Kramer (1949) stated that a decreased oxygen supply to the roots reduced their permeability to water. The roots of plants grown under conditions of oxygen deficiency are shorter, thicker, darker and have less numerous root hairs (Loehwing, 1937; Daubenmire, 1959).

Nutrient absorption by roots is one of the most important plant functions that is affected by low oxygen content. Harris and Van Bavel (1957) found that nutrient absorption remained relatively constant until the oxygen content was reduced below 10 percent. The order of sensitivity of the nutrients to oxygen concentration appeared to be K>N>P>Mg>Ca. Kramer (1950) demonstrated that phosphorus absorption was decreased to only 5 percent of the control by displacing all oxygen with nitrogen. When oxygen content was lower than 3 percent, both potassium and phosphorus intake was reduced (Hopkins et al., 1950). Iron chlorosis is frequently associated with poor soil aeration. Wallihan et al. (1961) observed that orange seedlings in calcareous soil developed severe iron chlorosis at low oxygen levels and that the concentration of iron and manganese in the leaf was reduced greatly due to low oxygen content.

Soil oxygen content also influences growth and production of plants through its effect on plant diseases (Bergman, 1959; Zentmyer, 1966). Poor aeration favors fungal growth which may retard plant growth.

Oxygen enters the soil and carbon dioxide leaves the soil through the air-filled pores. Several studies have shown that air-filled porosity directly controls oxygen diffusion and consequently soil oxygen content. For every soil there appears to be an optimum air-filled porosity. Flocker et al. (1959) related plant growth to changes in air-filled porosity. An air-filled porosity of 10 percent was the limiting value at which air could be exchanged in the soil. Optimum growth occurred in soils with air-filled porosities between 20 and 35 percent. Raney (1949) found that below 22 percent air-filled porosity there was a curvilinear relationship between oxygen diffusion and air-filled porosity, possibly due to closing of the connecting channels between the pores. Above 22 percent porosity the curves were approximately linear. Taylor (1949) demonstrated that the effective diffusion distance became smaller as porosity decreased. Grable and Siemer (1968) found that oxygen diffusion decreased to zero at or near air-filled porosities of 10 to 20 percent.

Differences in pore space among soils result from differences in texture and structure. These physical soil factors have an indirect effect on soil oxygen content. Black (1957) observed that air-filled porosity was less in fine- than in coarse-textured soils at equal water tension. Boyle and MacLean (1958) showed that oxygen diffusion rates increased with the size of soil aggregates at 20 cm tension in silty clay loam. Taylor (1949) indicated that, in general, increasing the bulk density of soils caused a decrease in oxygen diffusion. Grable and Siemer (1968) stated that bulk density and aggregate size had little influence on diffusion of gases through soil provided the soil contained more than 12 percent air-filled porosity.

The effective pore space for air movement within a given soil is inversely related to moisture content. Taylor (1949) observed little oxygen diffusion taking place at tensions lower than 20 cm of water. There was little effect of moisture on gas diffusion at tensions higher than 30 cm. Bruce and Webber (1953) demonstrated that the relationship between diffusion and moisture content was closely related to pore size distribution. The results of Rust (1957) suggest that moisture-blocked pores decrease diffusion more than pores blocked in other ways.

The major process involved in oxygen consumption in soils is biological respiration. It is probable that under certain conditions low concentrations of oxygen in soil may occur as a result of a temporary but marked increase in the rate of oxygen consumption by the soil, which cannot be readily offset by the normal process of diffusion.

Experimental Procedure

Relationship Between Soil Oxygen and Cotton Root Distribution

The experimental approach used in this study consisted of placing air-sampling devices at various depths throughout the soil profile and monitoring the oxygen content throughout the growing season. At the end of the growing season, representative root samples were taken at several depths in each soil profile.

This study was carried out on representative Mississippi River Alluvial soils in Tensas Parish. Five soil locations were selected at the Northeast Louisiana Experiment Station (Bruin and Mhoon soils in 1969; Bruin and two areas of Mhoon soil in 1970) and six locations were selected at Highland Plantation (Dundee, Mhoon and Tunica soils in 1969; Dundee, Tensas Complex and Tunica soils in 1970). The soils differed in elevation, texture and internal drainage. Dundee and Bruin soils are usually found on the crest of natural levees of the present and abandoned channels of the Mississippi River, Mhoon and Tensas soils at lower elevations, and Tunica soils at still lower elevations. For each of the 11 soil locations, three uniform sampling sites 100 to 200 feet apart were used. The average distribution of sand, silt and clay throughout the profiles is shown in Figures 1 and 2.

Bruin and Dundee soils are light-textured with up to 40 percent sand. Mhoon and Tensas soils are medium-textured and Tunica is a heavy-textured soil with 40 percent clay in the 0 to 2-foot depth. To obtain information on the amount of air space available for gas exchange in the soils, the relative volume of air, water and soil solids was determined. Figure 3 shows the air-filled porosity at the end of the 1969 growing season. Air-filled porosity was greatest in the Bruin and Dundee soils. Mhoon was intermediate and Tunica had the lowest air-filled porosity. Figure 4 represents air-filled porosity at the beginning rather than at the end of the 1970 growing season. Bruin, Dundee and

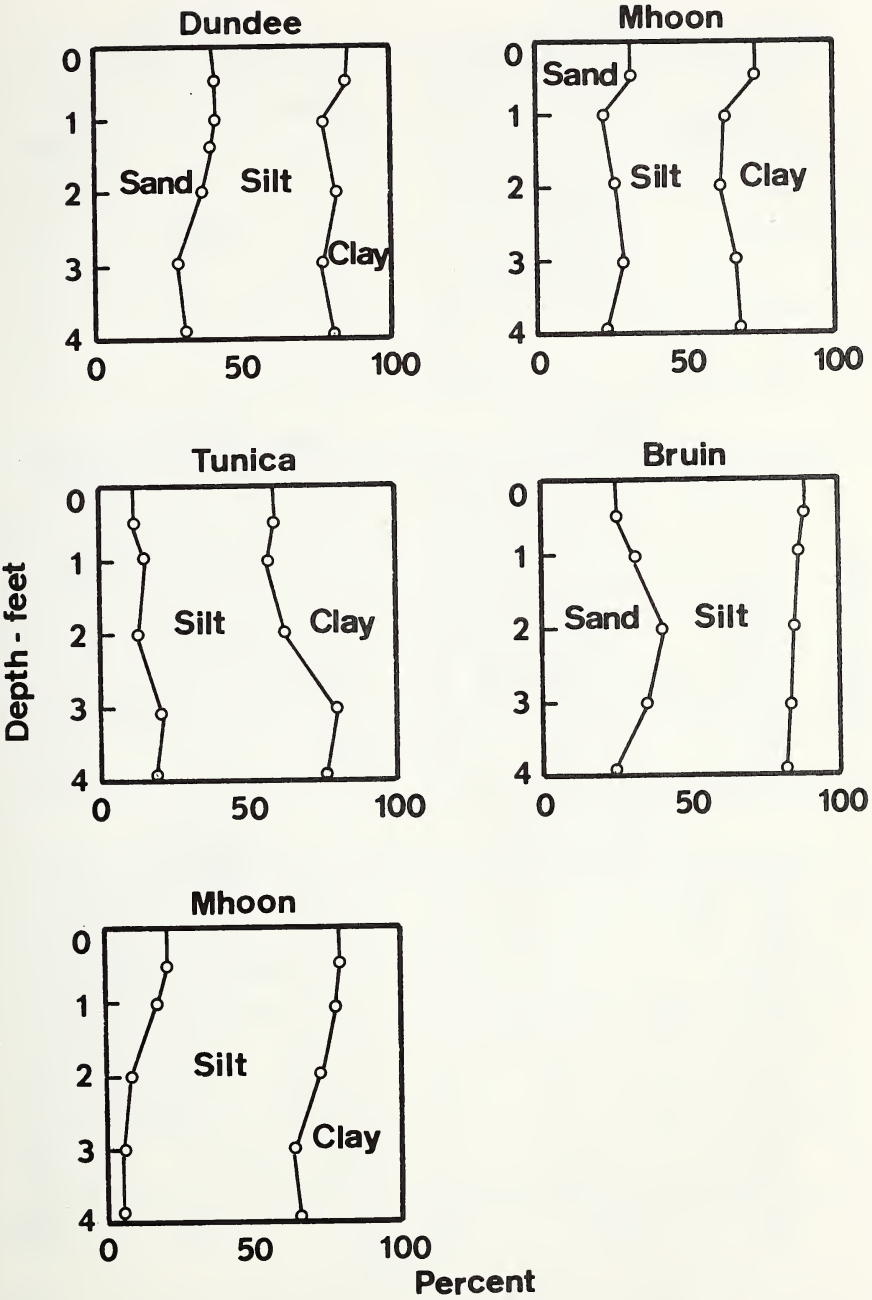

Figure 1.—Particle size distribution of Dundee, Tunica and Mhoon soils at Highland Plantation and Mhoon and Bruin soils at the Northeast Louisiana Experiment Station in 1969.

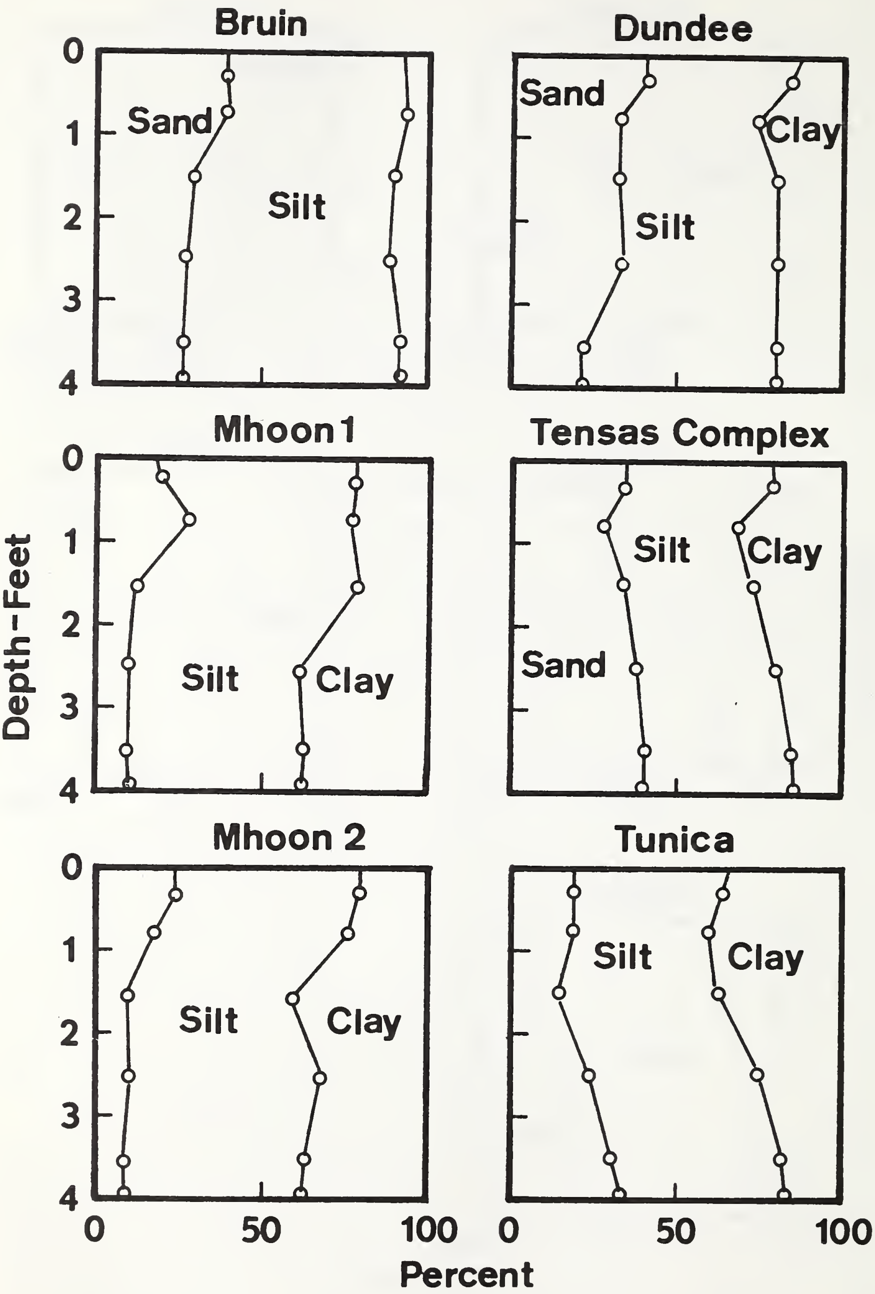

Figure 2.—Particle size distribution of Bruin, Mhoon 1 and Mhoon 2 soils at the Northeast Louisiana Experiment Station and Dundee, Tensas Complex and Tunica soils at Highland Plantation in 1970.

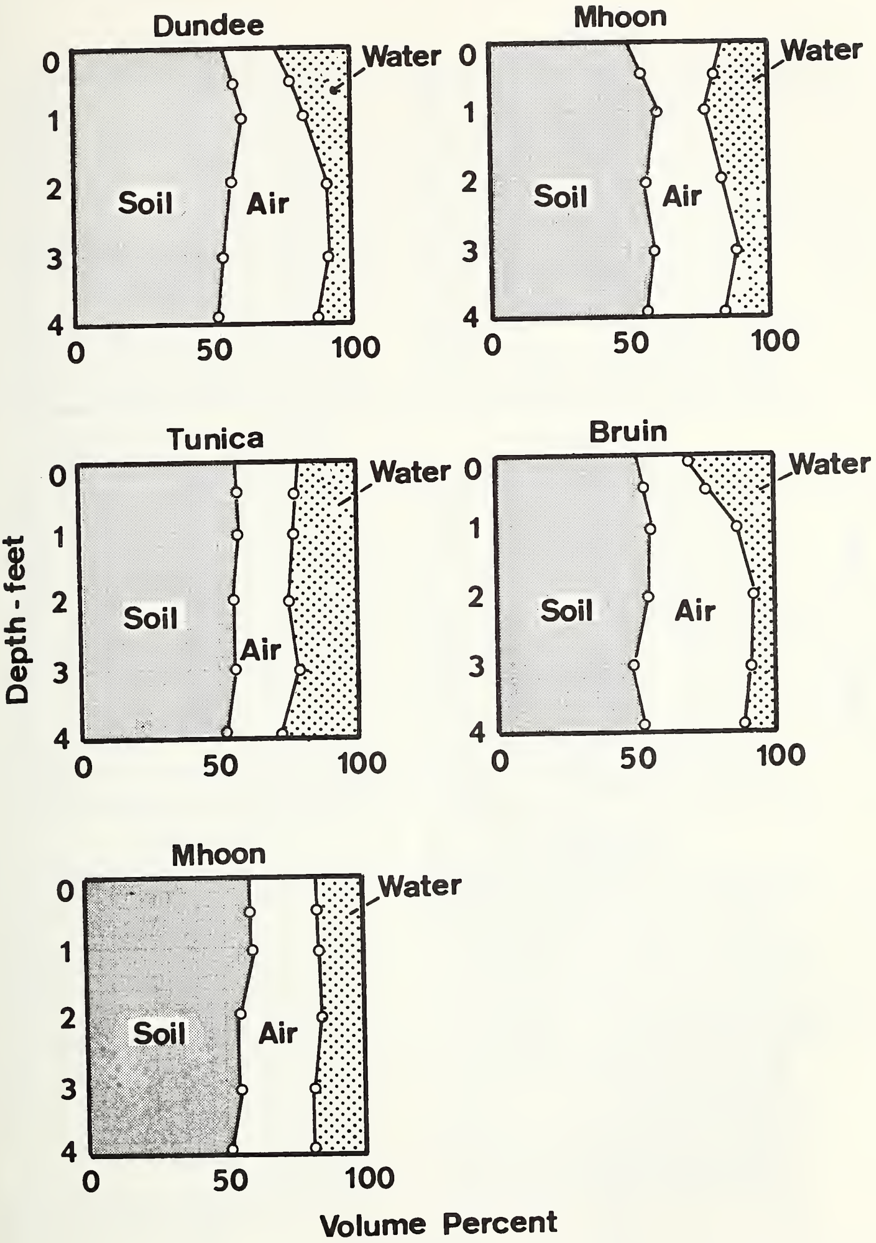

Figure 3.—Volume distribution of soil solids, air space and water at end of 1969 growing season for Mhoon and Bruin soils at the Northeast Louisiana Experiment Station and Dundee, Tunica and Mhoon soils at Highland Plantation.

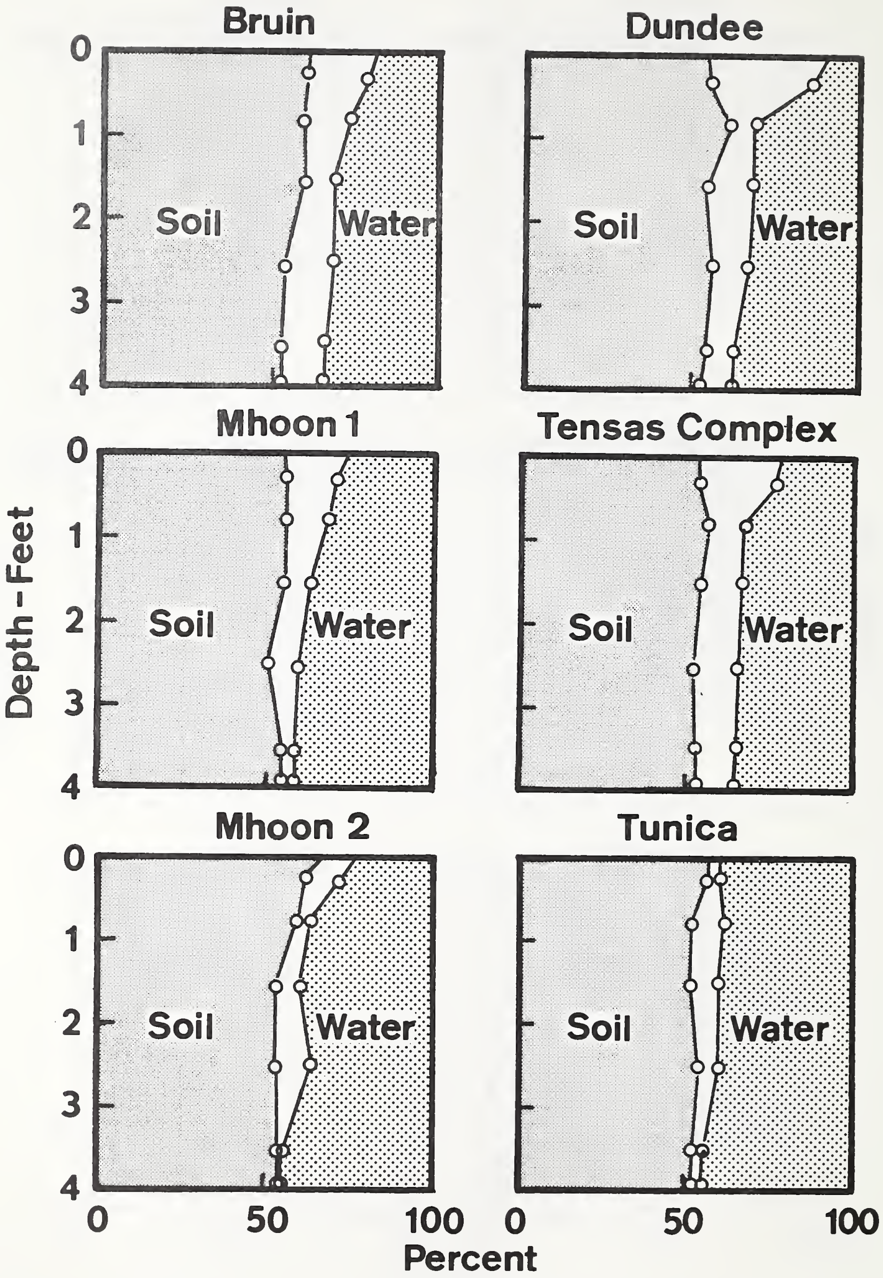

Figure 4.—Volume distribution of soil solids, air space and water at beginning of 1970 growing season for Bruin, Mhoon 1 and Mhoon 2 soils at the Northeast Louisiana Experiment Station and Dundee, Tensas Complex and Tunica soils at Highland Plantation.

Tensas soils had air-filled porosities generally greater than 10 percent. Mhoon and Tunica soils had air-filled porosities of less than 10 percent, a value at which normal exchanges of gases do not occur. Mhoon 2 and Tunica soils had these low porosity values throughout the profile.

Small air reservoirs were established in the soil at various depths for sampling and analyzing soil air. In constructing the soil air reservoirs a sampling tube ¾-inch in diameter was used to cut into the soil to a depth 2 inches greater than the desired sampling depth. A No. 4 rubber stopper was slipped on the end of a section of copper tubing of 1/16-inch inside diameter and forced into the hole far enough so that an opening 4 inches long was left below the stopper. In this way the reservoir was large enough to permit exchange of gases between the soil and the reservoir.

To prevent contamination with atmospheric oxygen, a 2-inch layer of plaster of Paris was poured into the hole and the remainder of the hole filled with soil. The tip of the copper tubing extended above the soil surface and was sealed with a small serum cap.

Soil air was drawn directly from the reservoir into a specially constructed cell containing a Clark-type membrane-covered polarographic oxygen electrode (Patrick et al., 1969). The cell was designed in such a way that the effective volume of the cell was less than 1 cc. The inlet for the oxygen analyzer cell was fitted with a small section of neoprene tubing which could be easily attached to the copper tubing. A syringe attached to the cell outlet was used to draw an air sample into the cell. Five to 10 milliliters of air drawn through the cell was sufficient for an accurate oxygen measurement. A battery-operated oxygen analyzer (yellow Spring Model 51) was used for analysis of oxygen.

Excavations were made at each of the sampling sites at the end of the growing season to determine the distribution of cotton roots in the soil. Cylindrical volumes of soil approximately 8 inches in diameter and either 6 inches or 1 foot in length, corresponding to the oxygen sampling depth, were removed from each site. The roots were separated from the soil by washing, then dried at 65° C and weighed. The values reported are average weights of roots from three soil profiles.

Results and Discussion

Soil Oxygen Content

1969 Results. The soil oxygen content throughout the growing season for the Bruin and Mhoon soils at the Northeast Louisiana Experiment Station is shown in Figures 5 and 6. For the medium-textured, well-drained Bruin soil, aeration was adequate throughout the season with oxygen contents of approximately 20 percent at all depths in the soil profile. The three replicate sites showed close agreement in oxygen values.

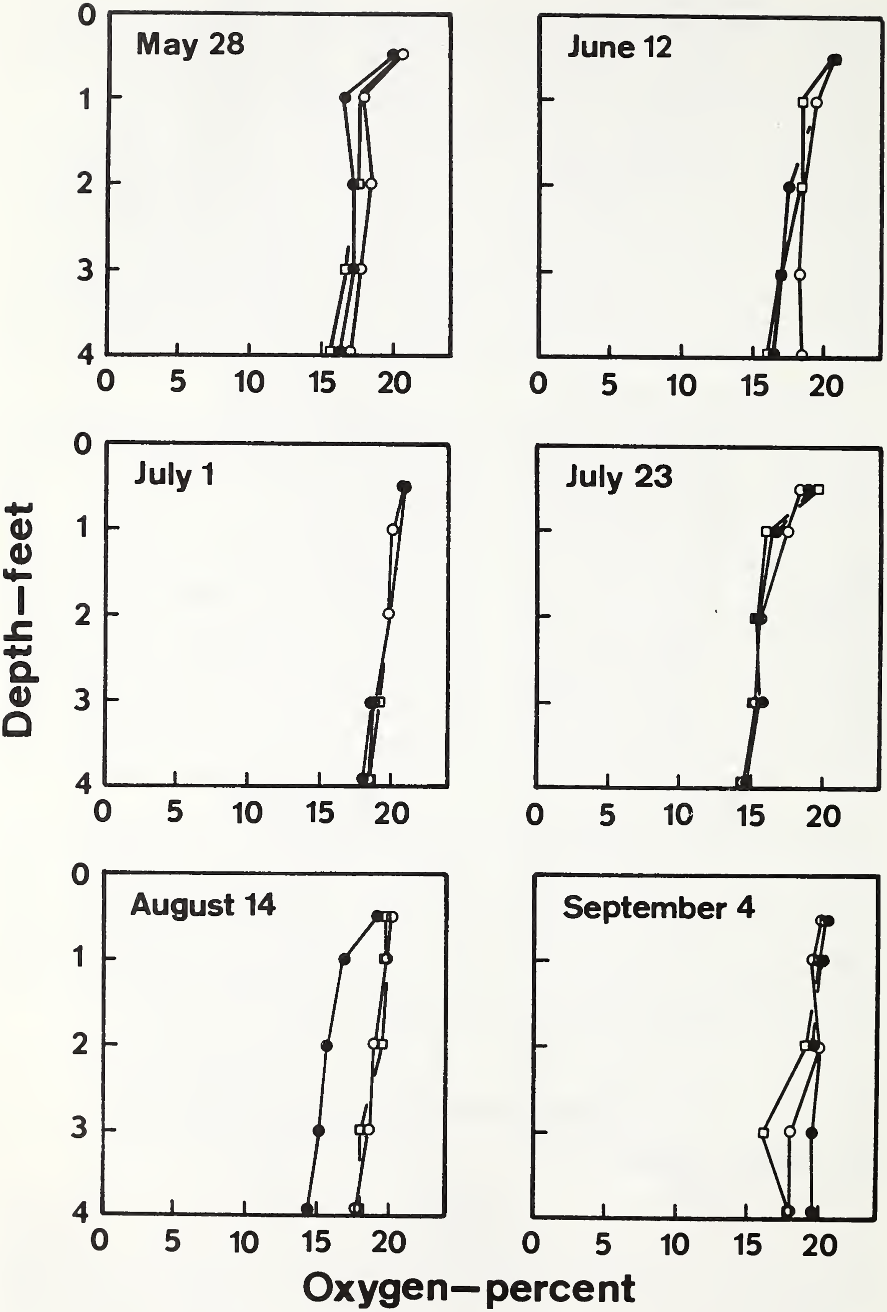

Figure 5.—Oxygen distribution in Bruin soil at the Northeast Louisiana Experiment Station in 1969.

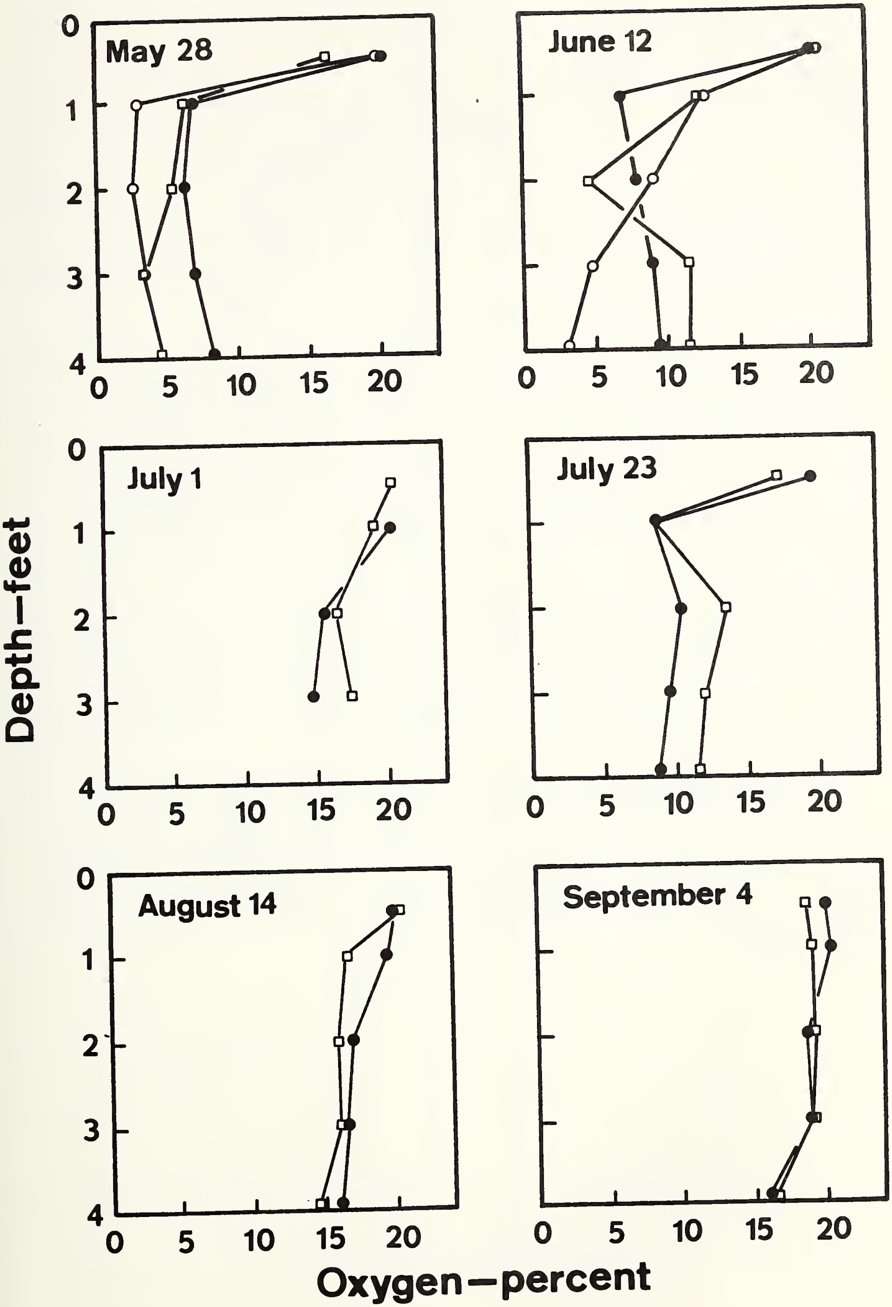

Figure 6.—Oxygen distribution in Mhoon soil at the Northeast Louisiana Experiment Station in 1969.

Oxygen measurements in the Mhoon soil showed that aeration in the lower profile was much more limiting than in the Bruin soil. At the 1-foot depth and below, oxygen content at the beginning of the growing season was at a level generally considered too low for adequate root development. As the season progressed there was a gradual increase in oxygen content in the subsoil, but adequate subsoil aeration was not evident until July. Because of poor internal drainage in the Mhoon soil, the soil pores contained too much water for oxygen to diffuse below the surface foot of soil. Moisture removal from the profile by downward drainage and moisture losses due to evapotranspiration as the season progressed allowed oxygen to penetrate deeper into the soil.

Oxygen measurements for the Dundee, Mhoon and Tunica soils at Highland Plantation are shown in Figures 7 through 9. For the well-drained Dundee profile, aeration was good throughout the season with the possible exception of the May 28 values, when oxygen content decreased to 10 percent at the 3-foot depth in all three replicate profiles and at the 1-foot depth in one of the replicate profiles. A water table was present between 3 and 4 feet on May 28 and June 12. During most of the growing season, however, no deficiency of oxygen was noted at any depth.

Aeration was much more critical in the Mhoon soil at Highland Plantation, especially during the first part of the season. This is shown in Figure 8. Only in the plow layer was aeration unrestricted early in the season. A water table was present between 2 and 3 feet at the first two sampling dates in May and June. Later in the season the water table receded below 4 feet.

Aeration was especially limiting in the poorly drained Tunica soil, as shown in Figure 9. Low oxygen contents were measured in the subsoil until the middle of August. At the June 12 sampling, oxygen content of the soil air at the 1-foot depth was 5 percent in two of the three replicates. A high water table was also present until the middle of the growing season.

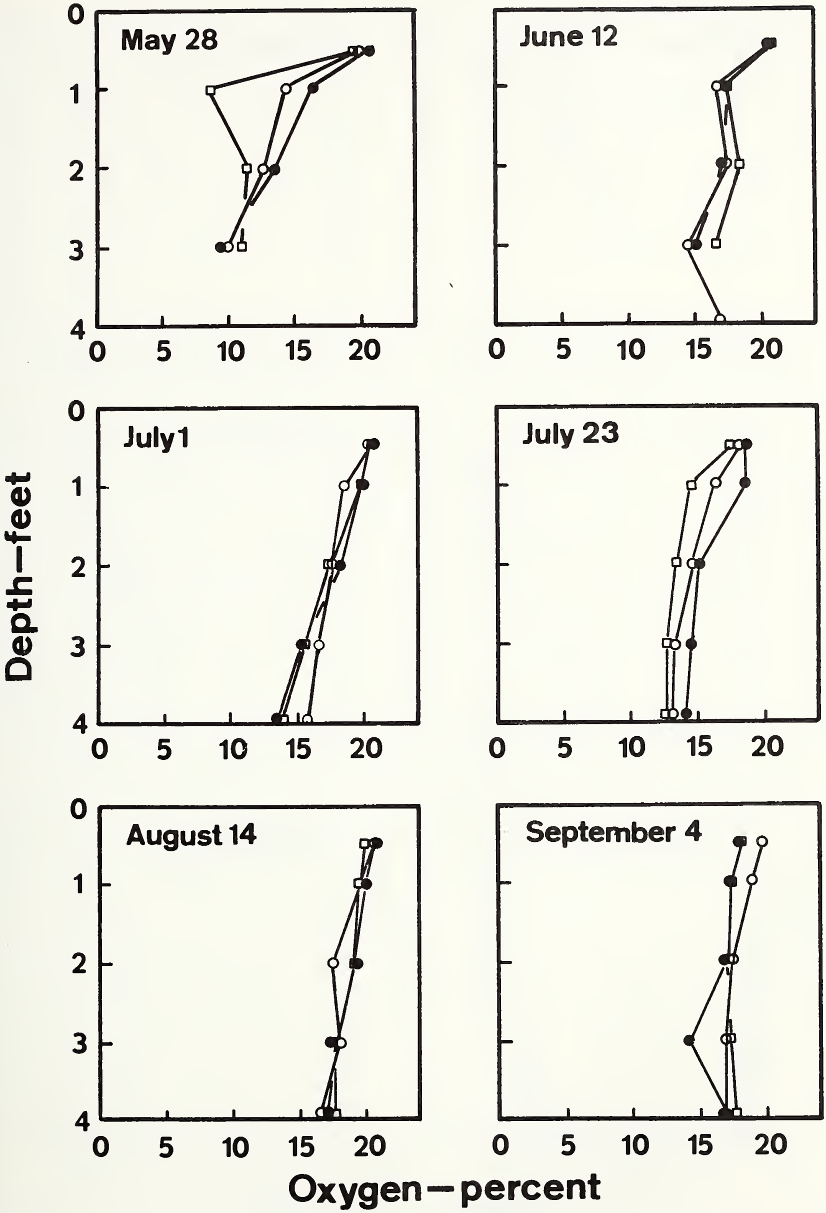

Figure 7.—Oxygen distribution in Dundee soil at Highland Plantation in 1969.

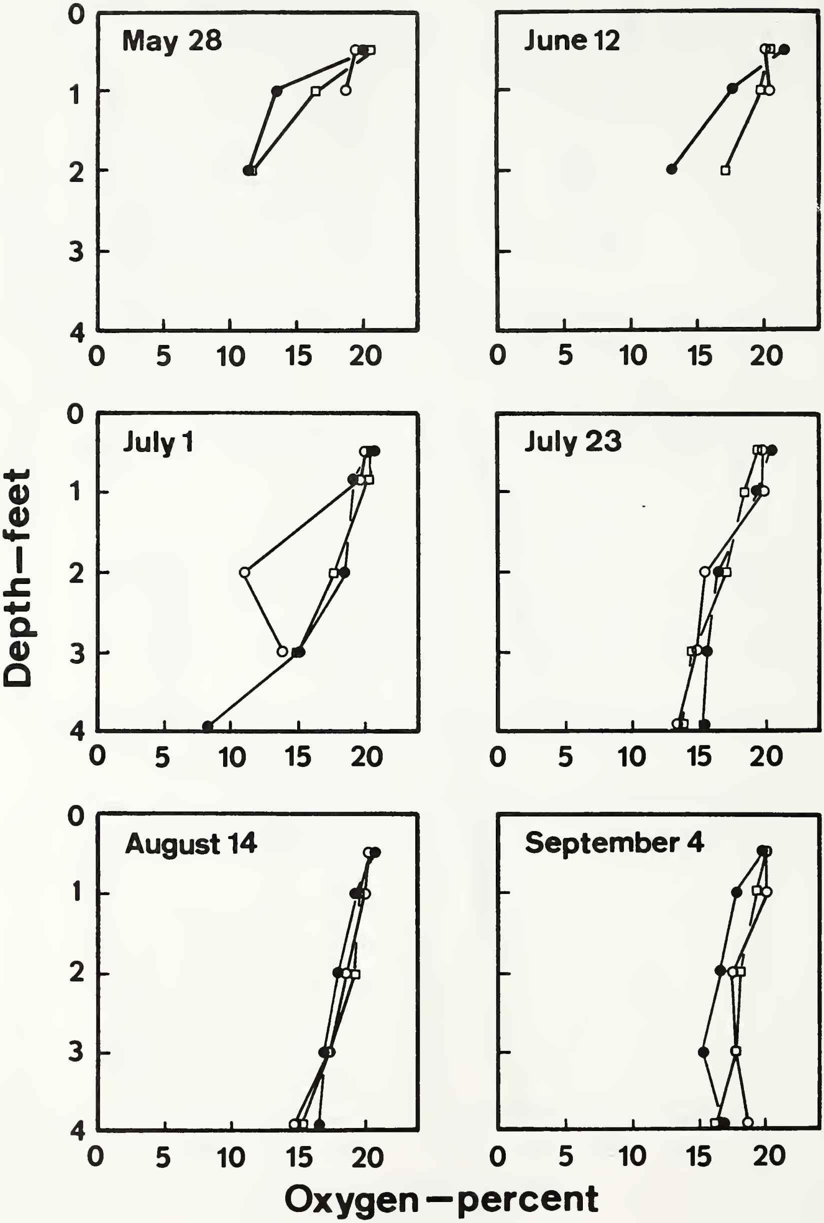

Figure 8.—Oxygen distribution in Mhoon soil at Highland Plantation in 1969.

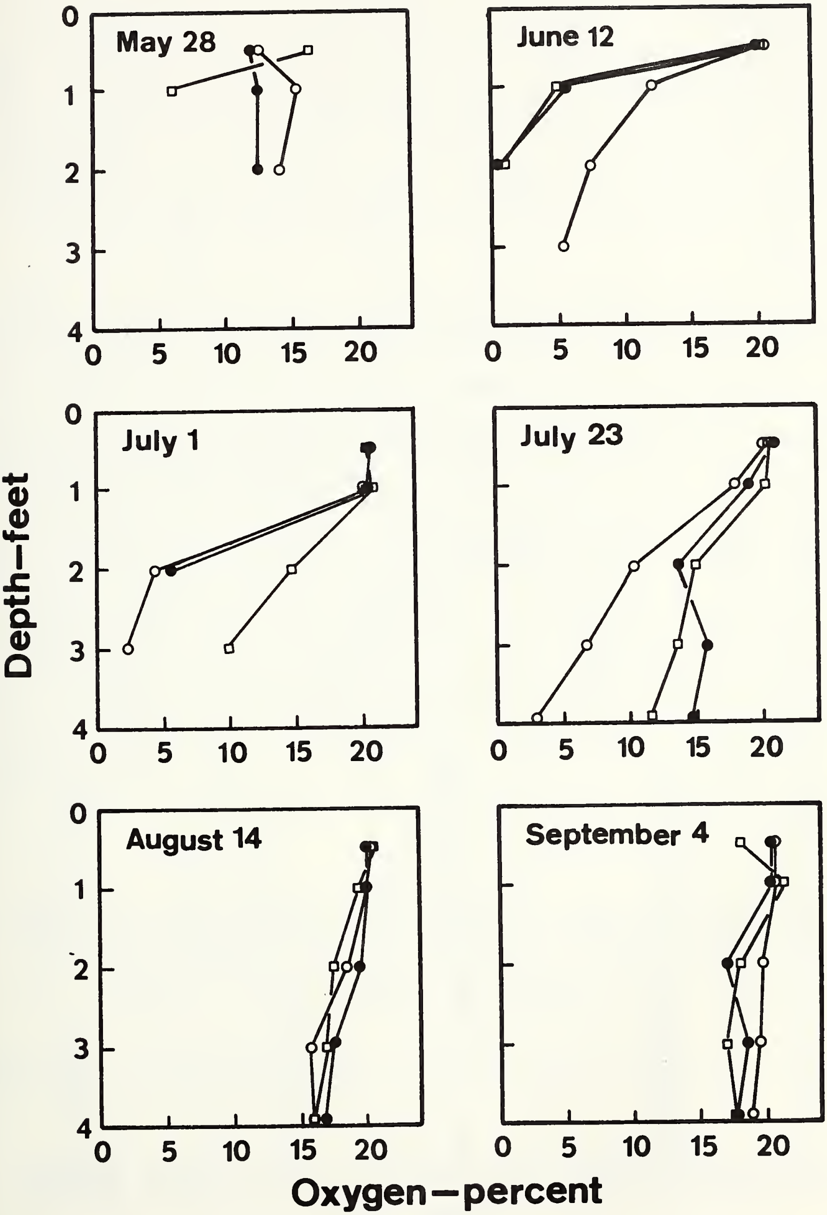

Figure 9.—Oxygen distribution in Tunica soil at Highland Plantation in 1969.

1970 Results. Oxygen measurements made in 1970 on Bruin, Mhoon 1 and Mhoon 2 soils at the Northeast Louisiana Experiment Station are shown in Figures 10 through 12. Measurements were made in the same general area for the Bruin soil. The Mhoon 2 soil used in 1970 was the same as the Mhoon soil of 1969. The Mhoon 1 soil was selected in 1970 because it was thought to be intermediate in drainage (and consequently aeration) between the Bruin and Mhoon 2 soils. Oxygen content in the Bruin soil was high throughout the profile, with no indication of any restriction in aeration. Heavy rains a day or two before the August 19 measurement had little effect on measurements taken on August 19, but resulted in slightly lower oxygen in the profile at the September 1 sampling.

The oxygen content of the Mhoon 1 soil was much more critical. During the early part of the growing season a marked decrease in oxygen content with depth was evident. At the 3- and 4-foot depths oxygen content was probably too low for adequate root growth. As the soil dried out due to downward drainage and evapotranspiration, aeration improved throughout the profile. The September 1 measurements showed a drastic decrease in subsoil oxygen. Rainfall filled the soil pores in the upper part of the profile and prevented air from diffusing into the soil. At the 2- and 3-foot depths the oxygen content was below 5 percent. Such a low oxygen content persisting for several days probably resulted in root injury or, at the very least, in unfavorable conditions for root growth. The unhealthy conditions of cotton plants on clayey soils following heavy rains lasting several days are very likely due to restricted oxygen and the unfavorable soil conditions that accompany low soil oxygen.

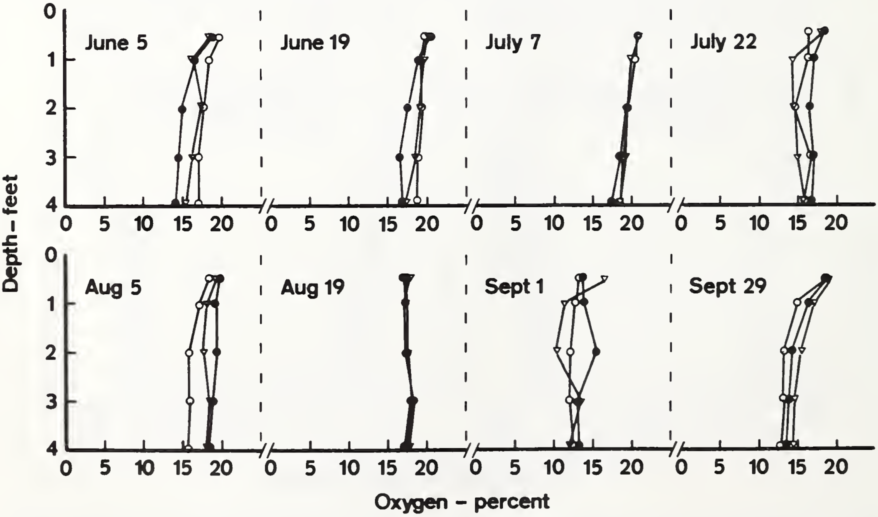

Figure 10.—Oxygen distribution in Bruin soil at the Northeast Louisiana Experiment Station in 1970.

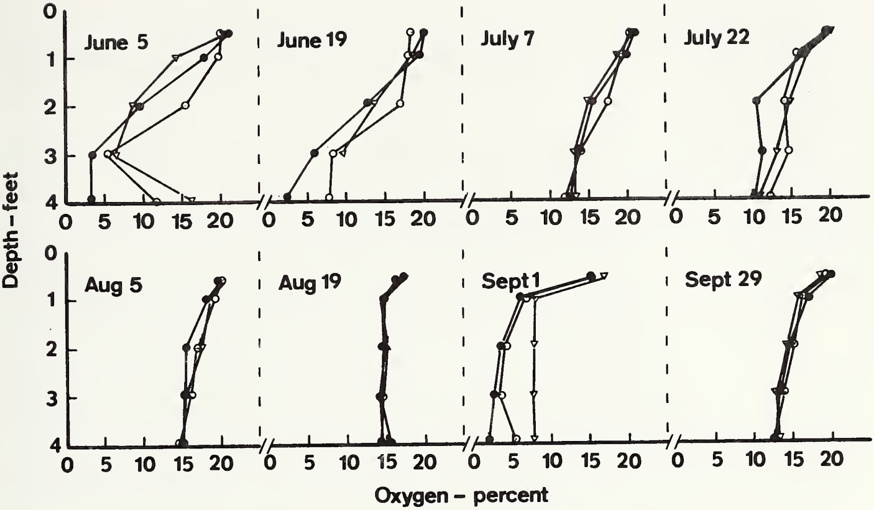

Figure 11.—Oxygen distribution in Mhoon 1 soil at the Northeast Louisiana Experiment Station in 1970.

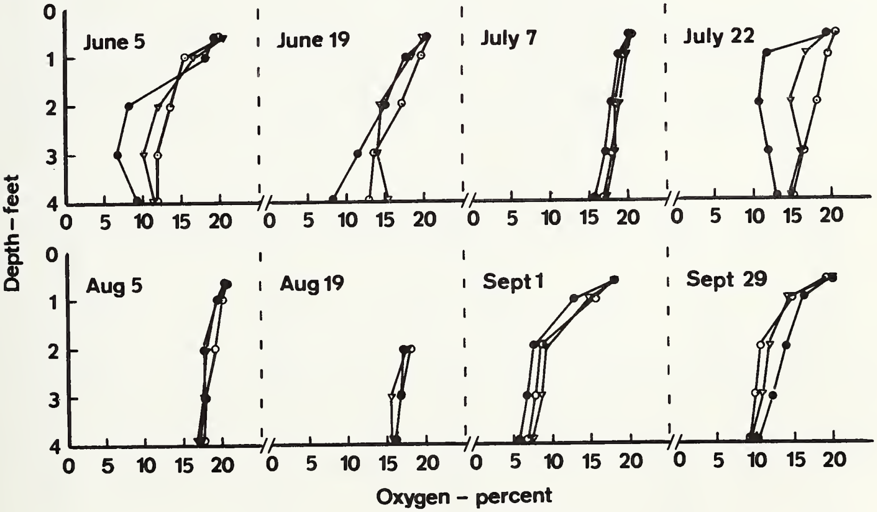

Figure 12.—Oxygen distribution in Mhoon 2 soil at the Northeast Louisiana Experiment Station in 1970.

Oxygen profiles in the Mhoon 2 soil were similar to those of the Mhoon 1 soil except for oxygen content being higher at the 3- and 4-foot depths in the Mhoon 2 soil at the beginning of the growing season. The effect of rainfall saturating the surface soil and decreasing oxygen in the subsoil was also observed. The sampling reservoirs at the 6-inch and 1-foot depths were saturated with water at the August 19 sampling and the effect on oxygen content in the subsoil was still evident at the September 1 sampling.

Oxygen distribution in the Dundee, Tensas and Tunica soils at Highland Plantation is shown in Figures 13 through 15. The Dundee soil, with adequate internal drainage, had ample oxygen except for slightly decreased values at the beginning of the growing season. The poorer drained Tensas and Tunica soils were sometimes low in oxygen. Rainfall in late August was not as great at Highland Plantation as at the Northeast Louisiana Experiment Station and no late-season decrease in subsoil oxygen was noted. Although oxygen was usually not as high as in the Dundee soil, the Tensas soil was not deficient in oxygen at any time during the growing season. In the Tunica soil, on the other hand, no oxygen was present at the 2-foot depth and below at the first sampling. Aeration in this soil was critical in the subsoil until the July 22 sampling. As the growing season progressed, withdrawal of water from the soil by downward drainage and evapotranspiration increased the air-filled porosity of the soil enough so that oxygen content improved.

The results of these oxygen measurements over a 2-year period at 11 locations in Mississippi River floodplain soils show that oxygen content in the soil profile was never limiting in the better drained, medium-textured soils, but that oxygen contents considered low enough to hamper root growth and development were evident in the finer textured, poorer drained soils. Oxygen was generally lowest early in the season

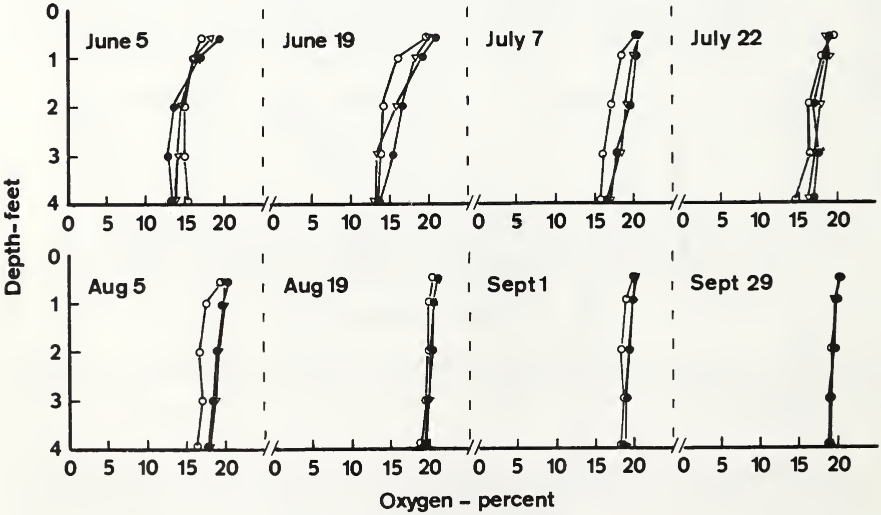

Figure 13.—Oxygen distribution in Dundee soil at Highland Plantation in 1970.

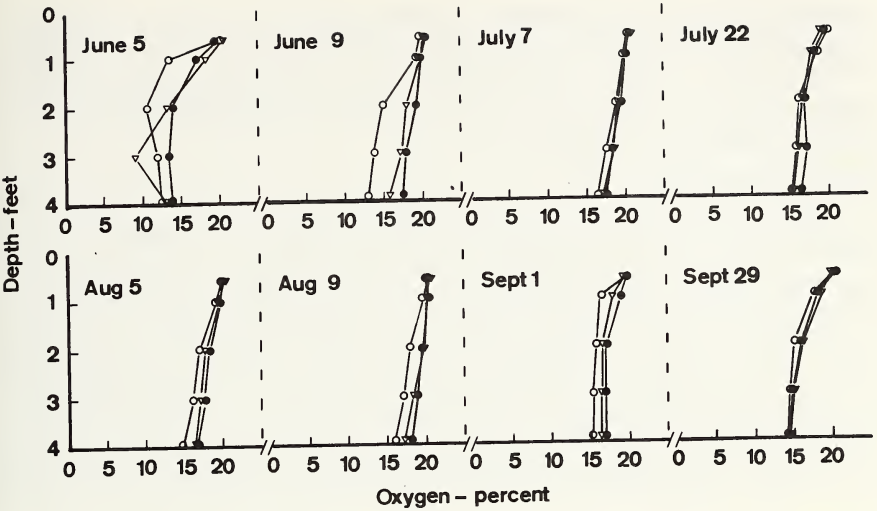

Figure 14.—Oxygen distribution in Tensas soil at Highland Plantation in 1970.

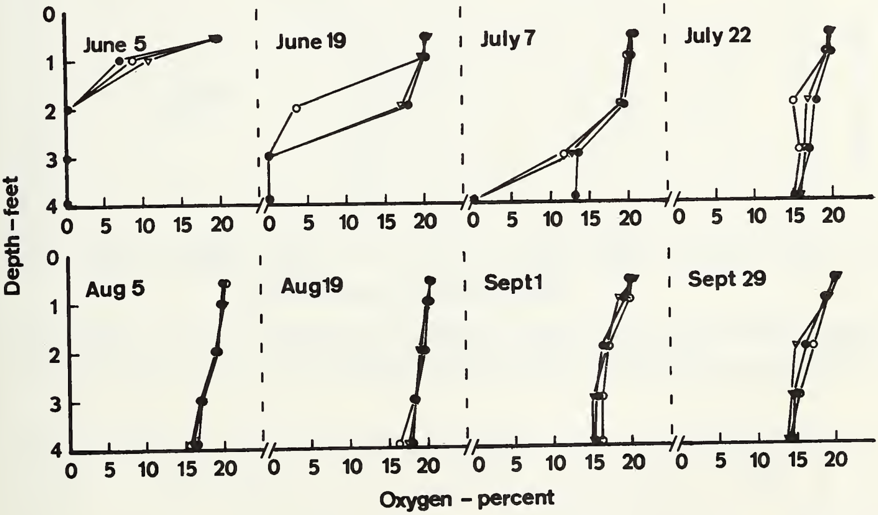

Figure 15.—Oxygen distribution in Tunica soil at Highland Plantation in 1970.

when the soil pores were still filled with water from winter and early spring rains. Water removed by downward percolation, evaporation and plant removal increased the air-filled porosity of the soil and consequently improved aeration as the season progressed. It was evident, however, that in these poorly drained soils heavy rains at any time during the growing season could block the soil pores enough to seriously restrict subsoil aeration. The specific effect of this late season depletion of oxygen is not known, but it is likely that if it persisted for many days serious root injury resulted.

Root Distribution

1969 Results. The amount of roots separated by washing in each of the soils is shown in Figures 16 and 17. As expected, most roots were concentrated in the surface foot of soil. Except for the fact that more roots were removed from all depths of the Bruin soil, differences among the soils in root distribution were not readily apparent. Root washing techniques are relatively inefficient in recovering all of the roots, and it is certain that factors such as soil texture affected the recovery of roots. For example, it is much easier to separate roots from medium-textured soils such as the Bruin and Dundee than from fine-textured soils such as

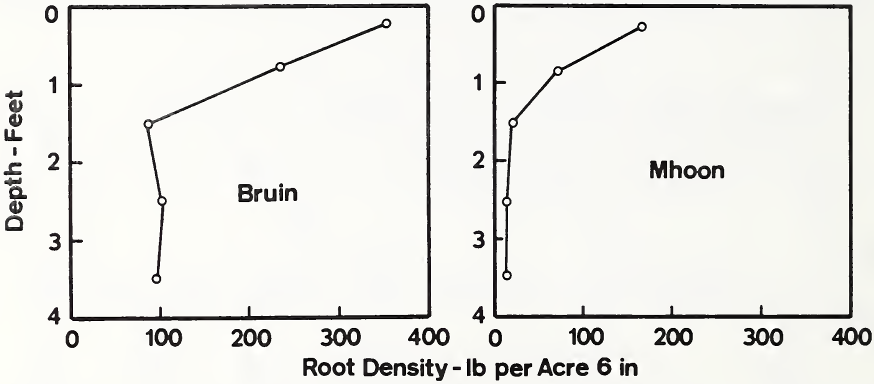

Figure 16.—Root distribution in Bruin and Mhoon soils in 1969. Each profile represents an average of three locations.

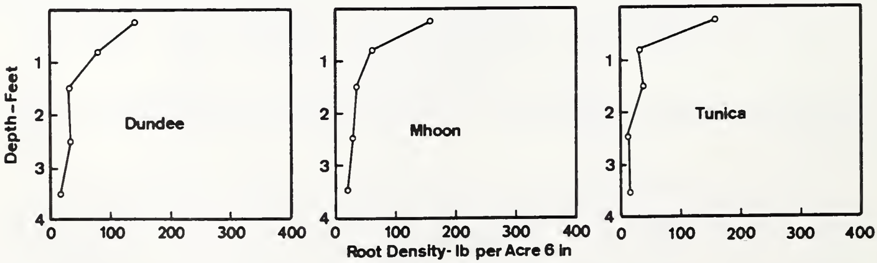

Figure 17.—Root distribution in Dundee, Mhoon and Tunica soils in 1969. Each profile represents an average of three locations.

Mhoon and Tunica. Nonetheless, it is likely that the root distribution data given here do indicate relative root activity at various soil depths since the measured values agree with visual observation.

1970 Results. Root distribution in the six soils is shown in Figures 18 and 19. These figures show more roots recovered in 1970 than in 1969. Most of the increase was probably due to a better separation technique rather than to more roots being produced in 1970. A converted automatic washing machine was used in 1970 for agitation of the soil and separation of the roots, rather than the hand operation used in 1969. The differences in root concentration in the surface foot apparently reflect differences in fertility and productivity of the soil rather than differences in aeration since all of the soils had adequate aeration in the surface foot for most of the growing season. There were differences in root concentration in the subsoil, however, which coincided with differences in soil oxygen content. The amount of roots in the 2- to 3-foot and the 3- to 4-foot depths was usually greater for the better aerated Bruin and Dundee soils than for the other soils.

In order to determine whether subsoil root development was related to soil oxygen during the growing season, plots were made of the amount of subsoil roots as a function of oxygen content during the 1970 season.

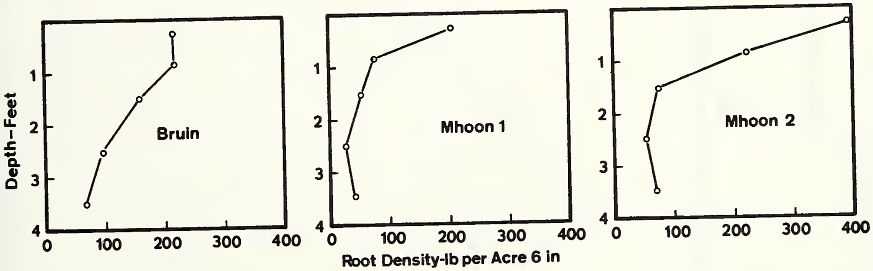

Figure 18.—Root distribution in Bruin, Mhoon 1 and Mhoon 2 soils in 1970. Each profile represents an average of three locations.

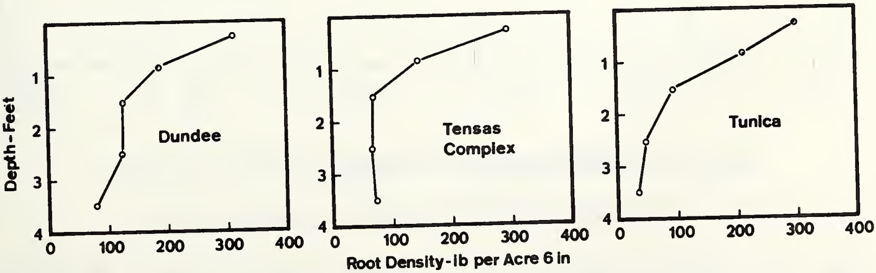

Figure 19.—Root distribution in Dundee, Tensas and Tunica soils in 1970. Each profile represents an average of three locations.

The closest relationship was found when subsoil root density was plotted against the average oxygen content at the 3-foot depth during June. Figures 20 and 21 show the relationship between these oxygen values and the amount of roots in the 2- to 3-foot depth and in the 2- to 4-foot depth. A fourfold increase in average June oxygen content from 5 to 20 percent was associated with a fourfold increase in subsoil root development. Although the amount of roots below the 2-foot depth was

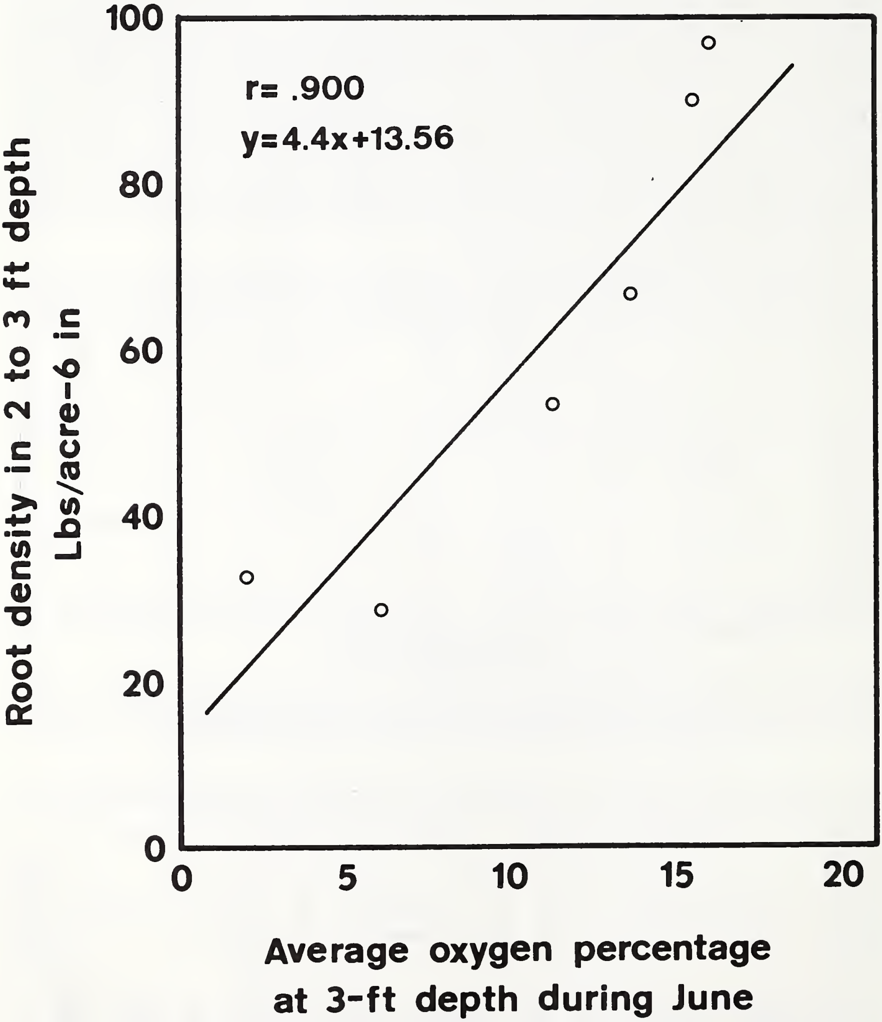

Figure 20.—Relationship between average oxygen content at the 3-foot depth during June and amount of roots in the 2- to 3-foot depth at end of growing season in 1970.

small, these roots occurring at lower depths are important for the growth of the crop. Beside their function in nutrient uptake, they serve a very important function in supplying water to the crop when available water has been depleted from the upper part of the soil profile.

It is very significant that subsoil oxygen content during June was most closely related to subsoil root development. During June the fine-textured, poorly drained soils were usually deficient in subsoil oxygen.

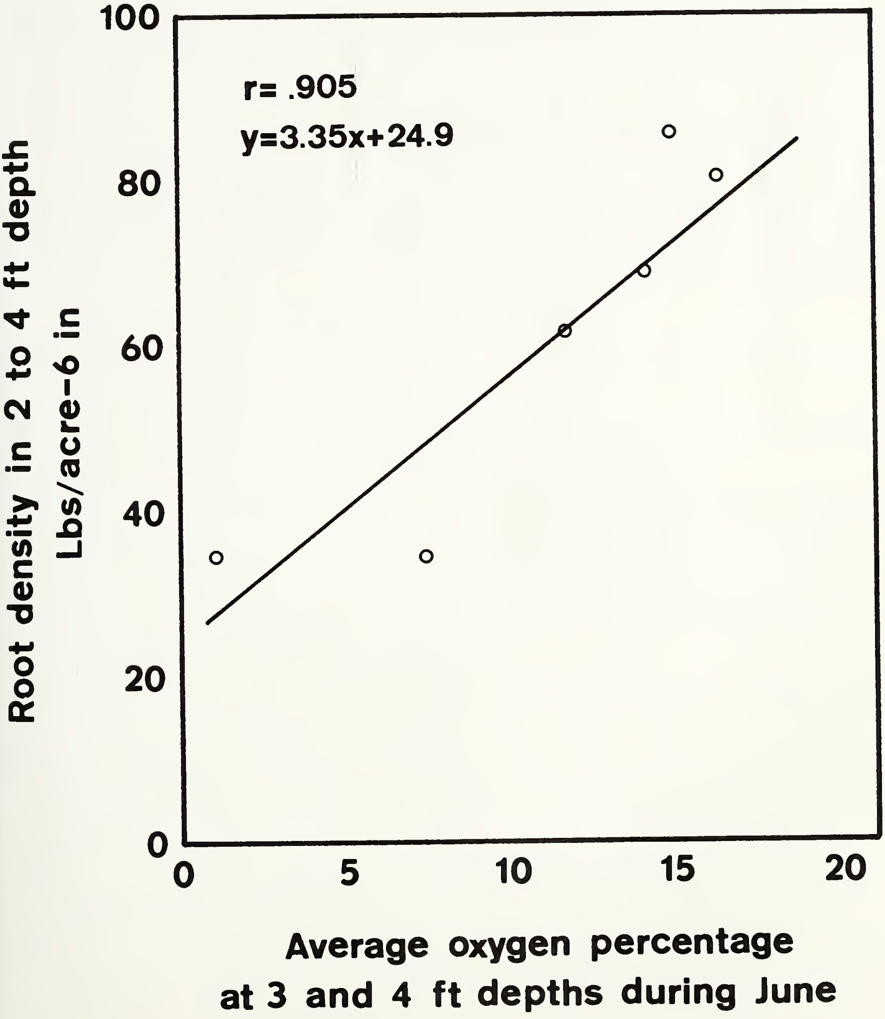

Figure 21.—Relationship between average oxygen content at the 3- and 4-foot depths during June and amount of roots in the 2- to 4-foot depth at end of growing season in 1970.

If it can be assumed that greater root penetration in the subsoil would be reflected in greater plant growth and yield, improved aeration in these soils should result in improved growth and yield of cotton. In almost all of the soils with poorly aerated subsoils, the oxygen status improved in July and August but this improvement was apparently too late to cause increased root development.

These results agree closely with results of a study of soil oxygen content and root development of sugarcane on Mississippi River Alluvial soils (Patrick et al., 1969). The amount of sugarcane roots developing below the 2-foot depth was closely related to the average oxygen content of the subsoil during the first part of the growing season. The information obtained in this study strongly suggests that improved internal drainage in the fine-textured Mississippi River Alluvial soils would improve soil aeration, which, in turn, should improve growth and yield of cotton. Such an improvement in internal drainage cannot be brought about by better surface drainage alone as is now practiced in this area, but will very likely require the installation of internal drainage structures such as tile drains.

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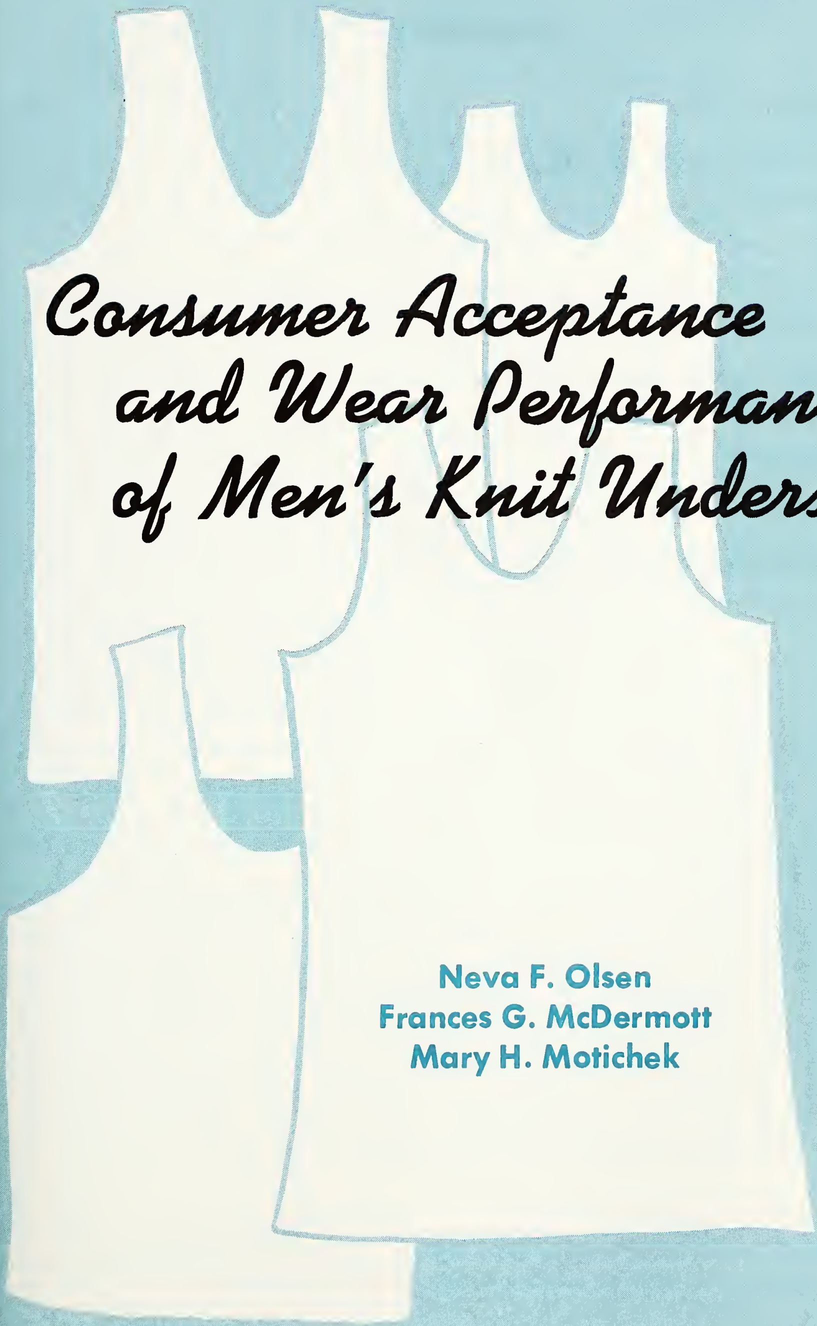

Consumer Acceptance and Wear Performance of Men's Knit Undershirts

Neva F. Olsen
Frances G. McDermott
Mary H. Motichek

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Consumer Acceptance and Wear Performance of Men's Knit Undershirts

Neva F. Olsen, Frances G. McDermott,
Mary H. Motichek[1]

INTRODUCTION

Cotton knit undergarments have had an important place in personal wardrobes for many years. However, knit goods manufacturers are now using a variety of fibers alone or in combination with the cotton fiber to replace the traditionally all cotton garments. In 1966, manufacturers used 188.3 million pounds of fiber for men's and boys' underwear which were largely composed of 100 percent cotton (*10*)[2]. The same year a total of 52,048,000 sleeveless, knit, athletic-type undershirts were produced and consumed (*6*). In 1968, a significant increase in production occurred. That year 58,044,000 sleeveless, knit, athletic-type undershirts were produced with a value of 28.7 million dollars (*12*). In 1971, 169.9 million pounds of fiber were used for men's and boys' knit underwear, with a definite increase in use of man-made fibers (*11*).

Few studies are available that compare the different fiber types of undershirts being used today in situations of actual wear. The consumer is not usually interested in identifying fibers per se, but is more concerned with how certain fibers will perform in a finished cloth.

When a study involves consumer behavior, an understanding of the consumer's social status and environment within society is automatically involved. Natural stratification is found within a society, and this exists locally as well as nationally (*2, 3, 6*). Many efforts have been made to describe social class in this country. The numerous studies of particular cities, towns, and areas make it clear that a given locale may have a relatively small or a relatively large number of class divisions, and that the criterion of each may vary considerably. There is no agreement about the number or size of social classes that exist in America (*2*). Reissman (*8*, p. 230) said, "classes are designated quite arbitrarily and frequently on the bases of occupation, residential area, income or education." Hollingshead also recognized the education and occupation variables by developing an Index of Social

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[2] Italic numbers in parentheses refer to Literature Cited, page 15.

Position which fulfills ". . . the need for an objective, easily applicable procedure to estimate positions individuals occupy in the status structure of the community" (*3*, p. 387).

Martineau concluded from a study by the Chicago Tribune that social class differences were more significantly determinant of buying behavior than was income (*5*). Class has been found to influence consumer behavior because values, life styles, goals, and behavior of the several classes were distinct and different (*8*).

The market for some consumer products is influenced by such factors as education and occupation. From a realistic point of view, these factors are highly influential (*9*). Men and women who possess similar educational backgrounds will tend to have similar tastes, similar attitudes, and similar behavior patterns (*4*). It is important to realize that there are far-reaching psychological differences between the various social classes. They do not think literally in the same way. The high social class and the middle social class consumers function in an environment which offers information if they have the motivation and the drive to accept it. However, the low income consumer does not even know that consumer information exists. In fact, he has no consumer awareness, except that he believes that living is expensive. He does not consciously think about the choices open to him.

Social classes are homogeneous in behavior. This is a particularly important assumption for consumer analysts, because it means that "members of a particular social class tend to buy the same products, shop at the same stores, and undergo similar decision processes" (*2*, p. 265). Each social class displays characteristic values and behavior patterns that are useful in analyzing consumer decisions (*2*). The knowledge that the individual acts in a social frame of reference determined by the group of which he is a member has been important to the understanding of human behavior.

The objectives of this study were: (1) to investigate the aesthetic and economic factors that consumers of three social classes considered in selecting, and evaluating after use, garments of varying fiber content; (2) to compare the wearing qualities of these selected undershirts as determined by laboratory analysis.

MATERIALS AND METHODS

Garments

Classic sleeveless, knit undershirts were the garments used in this study. Since these staple clothing items are less subject to fashion changes than outerwear, emphasis was placed on fabric rather than fashion features. The fiber composition of the undershirts was: 100 percent cotton, 50-50 percent cotton-polyester blend, and 100 percent polyester. Major brand name garments were chosen from undershirts available on the market. The 100 percent cotton and 50-50 percent cotton-polyester undershirts were tubular with a single filling knit in a ribbed pattern and were identical in price; the 100 percent polyester garments were made of tricot knit with side seams—the only type available on the market—and were the most expensive of the three types.

Participants

The participants were 120 married Caucasian men randomly selected from the Baton Rouge, Louisiana, area by the use of two reference directories (*1, 7*). Only men who were accustomed to wearing the sleeveless type undershirts and who wore them the entire year were accepted for the study. The 120 participants were categorized into high, middle, and low social class groups, with 40 men representing each group. Two factors—occupation and education—were utilized to determine social class (*3*). These two factors for each participant were computed from Hollingshead's system of seven scores. Multiple correlation techniques were used to determine the factor weights, which were as follows:

Factor	Factor Weight
Occupation	7
Education	4

The *Index of Social Position* score for an individual was calculated by multiplying the scale value for occupation by the factor weight for occupation, and the scale value for education by the factor weight for education. The social class to which the individual belonged was determined by the sum of these two scores. The Index was arranged into groups of scores as follows:

Social Class	Range of Computed Scores
I	11-17
II	18-27
III	28-43
IV	44-60
V	61-77

Respondents from social classes I and II were designated as the high social class, III as the middle social class, and IV and V as the low social class. These ranks assisted in establishing the homogeneity of the three social class groups within the sample (*3*).

Questionnaires were administered to the husband or wife who usually purchased undershirts. The first questionnaire consisted of four sections: background information, purchasing practices when selecting men's undershirts, factors considered when purchasing, and evaluations of the selected garments. During this evaluation phase, a representative shirt of each fiber type was shown the participant. At the end of the wear phase, participants responded to another questionnaire regarding the most comfortable and desirable undershirt. The questionnaires contained check sheets and open end questions.

Wear Phase

Three undershirts, one each of the selected fiber types, were distributed to each male participant. The participants were instructed to wear each shirt once per week for one calendar year and to launder them according to their individual laundering procedure. The questionnaire was also administered during this visit to determine what factors were considered when actually purchasing undershirts. Laundering procedures to be used were recorded. It was found that for this type garment, the majority used one-half cup of built synthetic detergent, agitated for 10 minutes in a hot water wash, and followed with a warm water rinse. Approximately one-half of the participants tumble dried their laundry, while the remaining one-half dried their clothing on an outside line.

Laboratory Evaluation

Laboratory tests were conducted on a selected number of new undershirts and on those which had been worn for one calendar year. The following tests were performed according to procedures established by the American Association of Textile Chemists and Colorists and the American Society for Testing and Materials: dimensional change, color difference, and bursting strength.

RESULTS AND DISCUSSION

Consumer Acceptance Phase

It was found that the respondents' wardrobes included an average of 6-8 undershirts, with more made from 100 percent cotton than from any other fiber type. There may be a possibility that some respondents were not aware of the fiber content of each shirt they possessed, since 30-45 percent stated that they did not inspect the label before purchase and a majority selected the cotton-polyester blend as the most desirable before and after wear.

The pattern of responses regarding the aesthetic and economic factors considered when purchasing showed no significant differences, according to the chi-square test, among the social class groups. Dimensional stability, comfort, brand name, and whiteness were the major factors given by those who knew what they considered when purchasing, as shown in Figure 1. Of the total participants, 31.7 percent did not know what factors or criteria they used. Implications are that an instrument other than a questionnaire would be needed for eliciting information from these unaware consumers. This seems to support the idea that the decision-making process is not entirely conscious. Since undershirts have little or no prestige connotation, this may have accounted for the 50-65 percent who do not open packaged shirts before purchase.

Knowledge of the retail price or actual wear for a one-year period

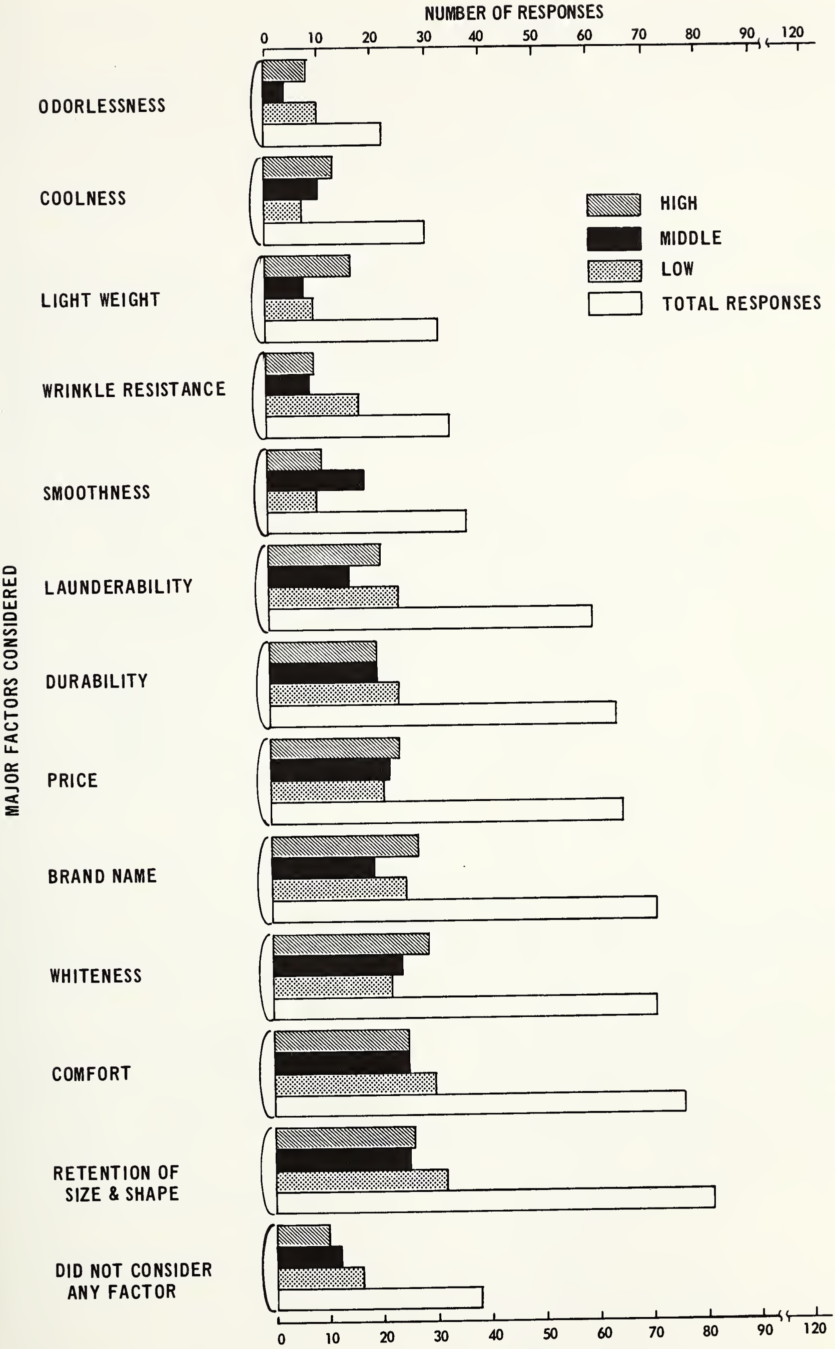

Figure 1.—Major factors respondents consider when purchasing undershirts.

did not change the opinion of the participants that the cotton-polyester blend was the most desirable and comfortable. However, after wear, dimensional stability and fabric softness were the major reasons given for this selection. A majority of the participants rejected the 100 percent polyester undershirts after a few weeks of wear; therefore, these undershirts were removed from the laboratory evaluation phase.

Laboratory Evaluations

Data obtained from laboratory analysis of the undershirts, before and after wear, were subjected to a 2 x 3 factorial analysis of variance.

Strength.—Strength of the new and worn undershirts was determined by using the Scott Tester with ball burst attachment. Mean square values for strength showed significant differences for social class and were highly significant for the fiber content (Table 1). As expected, both the all cotton and cotton blend undershirt fabrics among all social classes lost strength after the one-year wear period, even though the strength of the shirts worn by the high social class was greater.

Table 1.—Mean square values for strength of cotton and cotton blend undershirts

Source	d.f.	Mean Square
Total	179	
Fiber	1	70908.1709**
Class	2	341.3867*
Fiber x Class	2	121.0971
Error	174	76.0945

*Significant at the .05 level.
**Significant at the .01 level.

The ball burst strength of the new cotton-polyester undershirts was 92.80 pounds per square inch as compared with 58.46 for the all cotton (Figure 2). After the wear period the mean strength for the cotton-polyester was 80.44 pounds and for the cotton, 40.74 pounds. Wear and laundering reduced the strength of the cotton-polyester more than the cotton; however, the cotton blend continued to be stronger after the wear period.

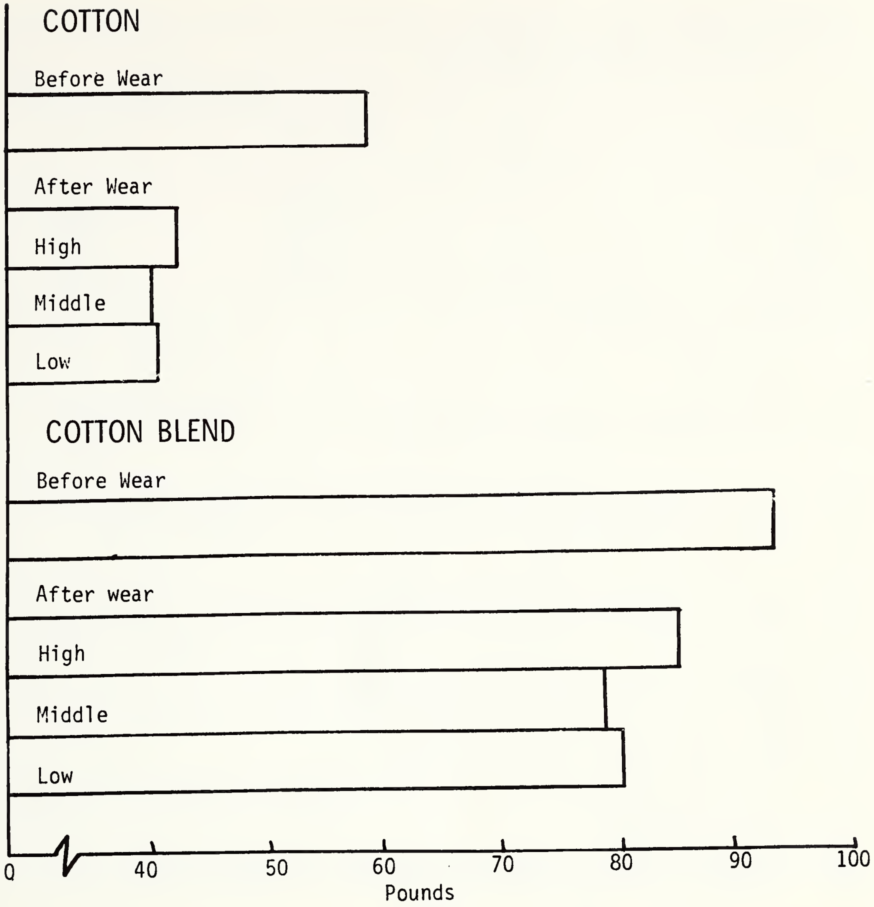

Figure 2.—Bursting strength of cotton and cotton blend undershirts before and after one year of wear by three social class groups.

Dimensional Change.—Dimensional change was determined by measuring shirts before and after wear in the lengthwise and crosswise directions to the nearest 1/10 inch.

Highly significant differences were found for the dimensional change of the undershirts due to fiber content (Table 2). Social class was not a significant factor. Shrinkage occurred in the length of both the cotton and cotton blend shirts, with more shrinkage found after wearing for the cotton than for the cotton-polyester (Figure 3).

The new cotton undershirts were 31.6 inches in length before, and 25.1 inches after, the wear period, thus showing a shrinkage of 6.5 inches, or 20.6 percent. Shirts consisting of cotton-polyester were originally 32.8 inches in length, and after wearing were 28.4 inches, showing a mean shrinkage of 4.4 inches, or 13.4 percent.

Table 2.—Mean square values for dimensional change of cotton and cotton blend undershirts

Source	d.f.	Mean Square	
		Lengthwise	Crosswise
Total	179		
Fiber	1	492.693556**	392.586605**
Class	2	0.863052	0.094877
Fiber x Class	2	1.015894	1.439212
Error	174	0.989822	1.649264

**Significant at the .01 level.

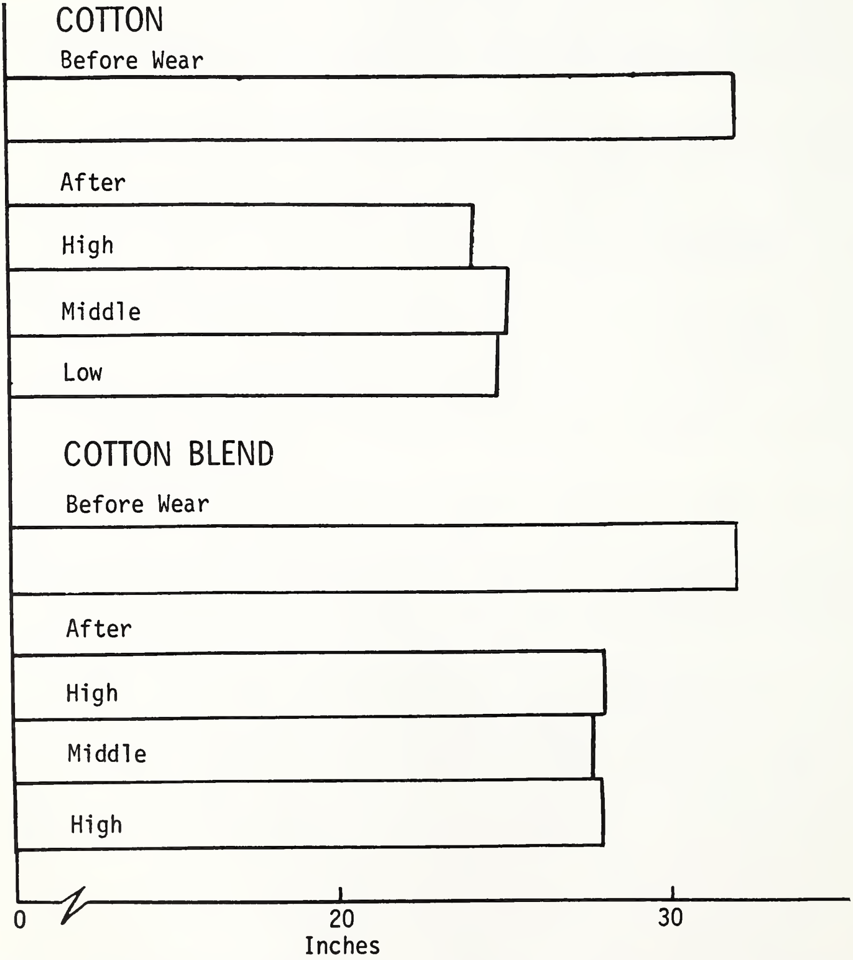

Figure 3.—Lengthwise dimensional change of cotton and cotton blend undershirts, before and after one year of wear by three social class groups.

When measured in the crosswise direction, it was found that the cotton undershirts stretched 2.8 inches and the cotton-polyester 0.2 inch (Figure 4).

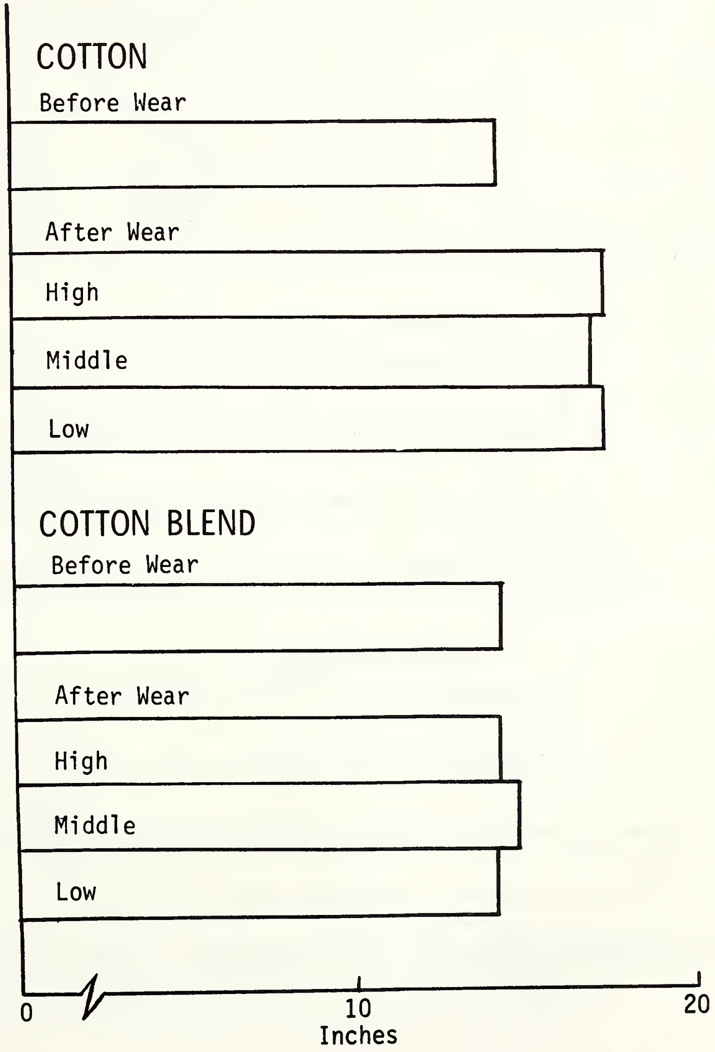

Figure 4.—Crosswise dimensional change of cotton and cotton blend undershirts before and after one year of wear by three social class groups.

Color Difference.—Color difference measurements were made using a Hunterlab Model D25 Color Difference Meter. The *L, a, b* scale of the model D25 gives measurements of color in units of approximate visual uniformity throughout the color solid. Highly significant differences for the *L* factor were due to fiber content, while *a* and *b* value changes were highly significant due to social class (Table 3).

Table 3.—Mean square values for color difference of cotton and cotton blend undershirts

Source	d.f.	Mean Square		
		L	*a*	*b*
Total	179			
Fiber	1	444.247380**	0.07160056	0.0322672
Class	2	8.719954	3.56317056**	27.5387039**
Fiber x Class	2	1.175502	0.41730722	1.4913206
Error	174	6.405019	0.71010489	4.3436217

**Significant at the .01 level.

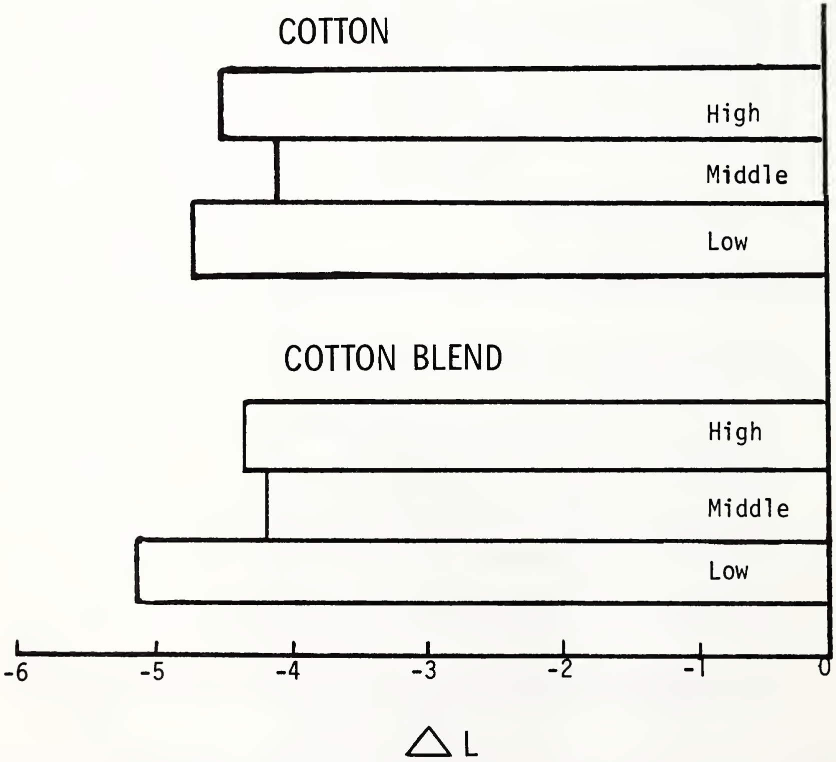

Figure 5.—Color difference of cotton and cotton blend undershirts after one year of wear by three social class groups.

The *L* measures lightness and varies from 100 for perfect white to zero for black. Both the all cotton and the cotton-polyester undershirts became darker after wear and laundering, with the cotton blend becoming darker than the cotton. The mean *L* value after wearing for cotton was —4.45 as compared with —4.57 for cotton-polyester, showing a significant difference due to fiber content (Figure 5).

The *a* measures redness when plus, gray when zero, and greenness when minus. Greenness increased after wearing, with shirts worn by the high social class group containing less than those worn by the middle and low social class groups (Figure 6).

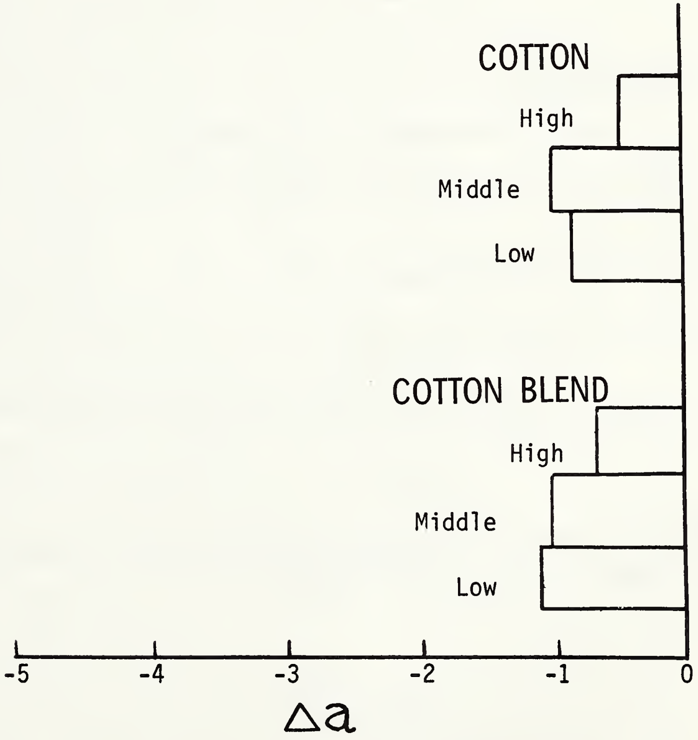

Figure 6.—Color difference of cotton and cotton blend undershirts after one year of wear by three social class groups.

The *b* measures yellowness when plus, gray when zero, and blueness when minus. Both types of shirts yellowed with wear and laundering, with the shirts worn by the high social class group yellowing least (Figure 7).

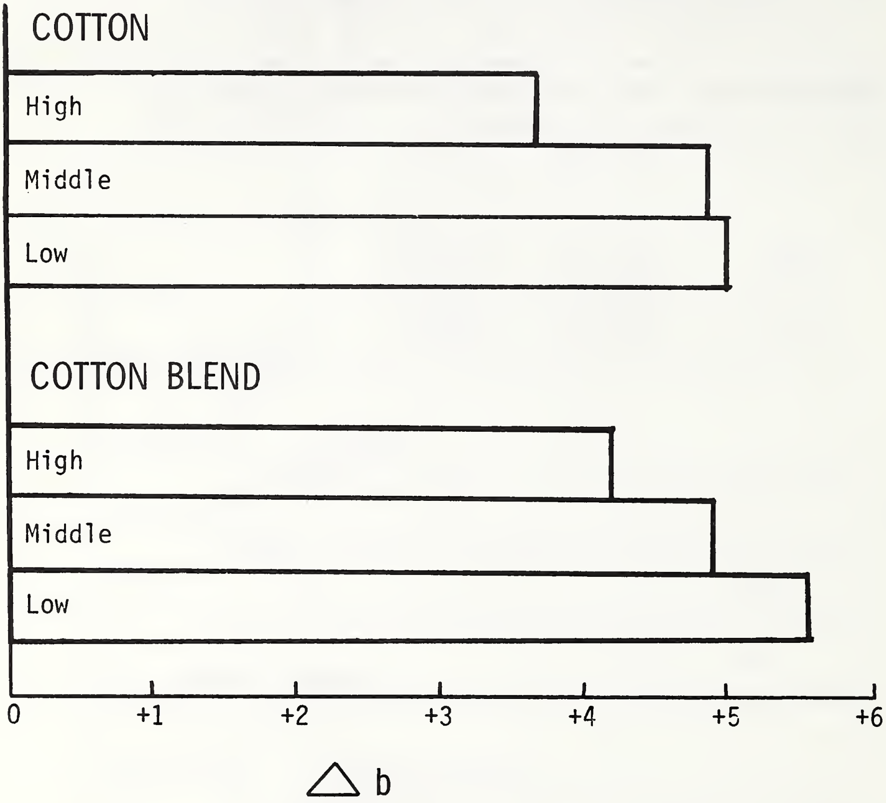

Figure 7.—Color difference of cotton and cotton blend undershirts after one year of wear by three social class groups.

SUMMARY

In summary, no significant differences in purchasing practices of respondents were found due to social class. This may imply that the social class to which a consumer belongs has little effect on his purchasing habits and use of staple items such as undershirts. Differences in wearing qualities due to fiber content were highly significant in most instances. This study also points up the fact that even though consumers say that they prefer cotton and select this fiber, almost 45 percent do not check the label for fiber content and may actually be using blends with cotton rather than 100 percent cotton. This may also be due to the fact that many cotton blends have almost the same appearance and hand as 100 percent cotton.

The high rejection of the 100 percent polyester, and the acceptance of the cotton blend as most desirable, emphasized the need for a better process to stabilize cotton knit fabric to prevent shrinkage and stretching. Certainly, because cotton remained whiter than the cotton blend after wearing, it is highly desirable; but consumers did not feel that whiteness was as important during wear as dimensional stability and softness.

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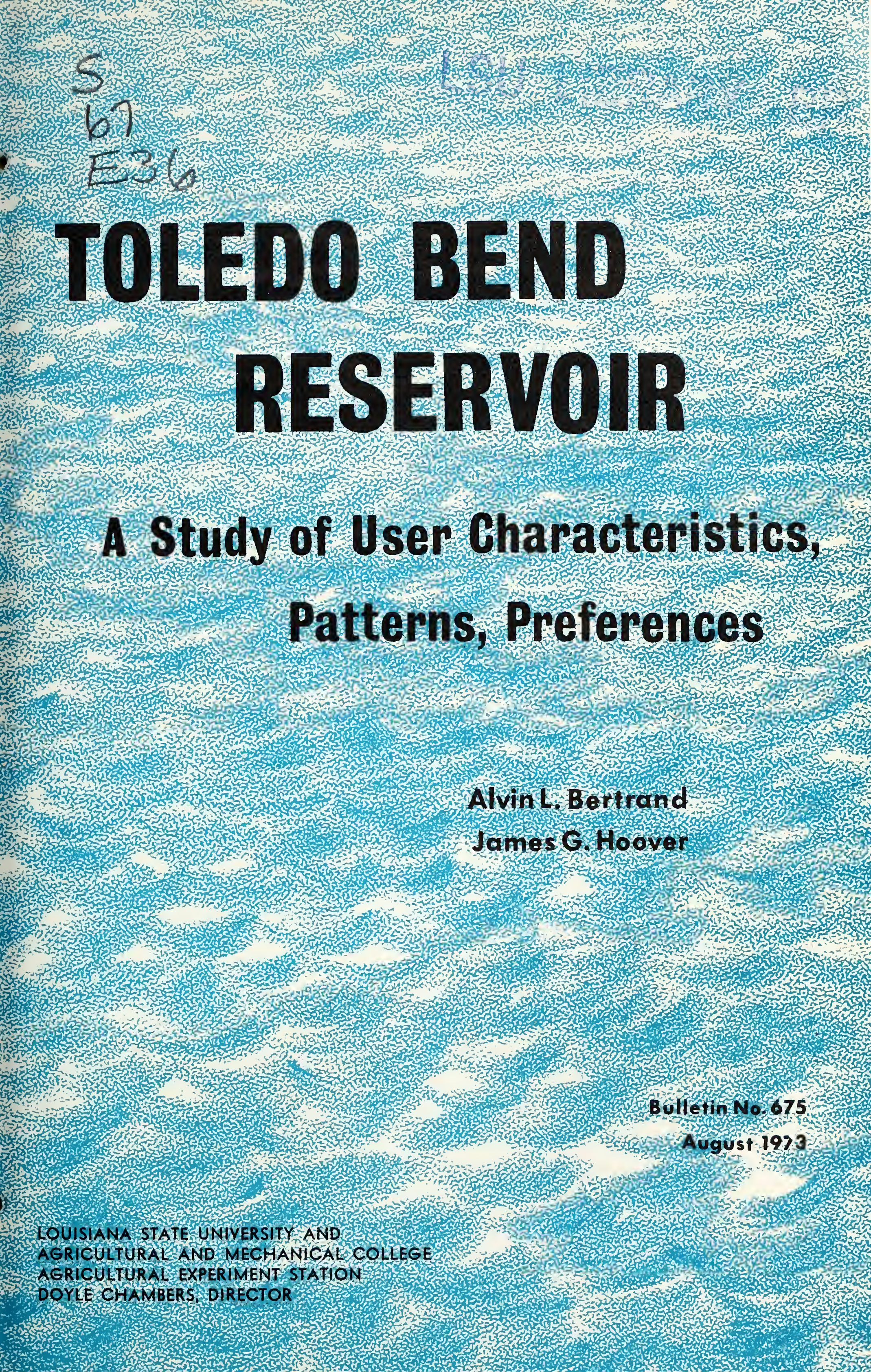

TOLEDO BEND RESERVOIR

A Study of User Characteristics, Patterns, Preferences

Alvin L. Bertrand
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Toledo Bend Reservoir

A Study of User Characteristics, Patterns, Preferences

ALVIN L. BERTRAND AND JAMES G. HOOVER*

Introduction

Within recent years the evolving social climate in the United States has made it increasingly clear that more opportunities for outdoor recreation are needed. Two trends have been noted especially. On the one hand, more and more Americans are engaging in outdoor recreation activities as a result of increased leisure, and on the other hand existing natural resources suitable for recreation purposes are rapidly diminishing. The latter relates to matters of alternative uses of resources or failure to follow proper conservation practices.[1]

In light of the above and in keeping with the current emphasis on rural development, the opening in a rural area of a new facility with a large recreation potential has research relevance. Toledo Bend Reservoir presents such a phenomenon. Although it was designed as a multipurpose facility, it has attracted a large number of recreationists in its first few years. This study was designed to provide benchmark data on those using Toledo Bend for recreation at an early point in its existence.

Objectives of the Study

The study made of Toledo Bend users had three general objectives. The first was to provide basic information of interest to planners in various state and other agencies concerned with the past and future development of Toledo Bend Reservoir as a recreation facility. In this regard, it was considered that information on characteristics of users of Toledo Bend Reservoir would be most helpful to planners.

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*Professor, Departments of Sociology and Rural Sociology, and Research Associate, Department of Rural Sociology, respectively, Louisiana State University.

This study is part of an overall project, aspects of which are being conducted in the School of Forestry and Wildlife Management and the Department of Agricultural Economics and Agribusiness, as well as the Department of Rural Sociology Research.

[1] It is appropriate to note that many government and private agencies are aware of these problems and have established policies and programs to deal with them. See for example: *Resources in Action: Agriculture 2000* (Washington, D.C., U.S. Department of Agriculture, 1967), pp. 14-17; *Environmental Quality* (Washington, D.C., First Annual Report of the Council on Environmental Quality, 1970), and *Recreation Symposium Proceedings* (Upper Darby, Pa., Northeastern Forest Experiment Station, Forest Service, USDA, 1971), pp. 186-200.

The second major objective was to determine the relationships between usage patterns and user characteristics. It was considered of relevance to relate recreation behavior to such variables as age, occupation, income, education, and place of residence. Information of this type will be of predictive value to those interested in developments such as Toledo Bend.

A third objective was to contribute to the sociology of natural resources development and outdoor recreation. This objective is inherent in the disciplinary nature of the research project.

Historical Background

Agitation for a dam and reservoir on the Sabine River border of Texas and Louisiana began as far back as 1949. However, it was not until 1958 that both the Texas and Louisiana legislatures granted authority to issue bonds for development and building of such a facility. In 1960, Louisiana voters passed a constitutional amendment authorizing the Toledo Bend Dam project. Texas already had this authority. Groundbreaking ceremonies were held in 1961 and flooding was completed by May of 1968. The dam and powerhouse were dedicated in October of 1969.

The dam and lake were built entirely through a cooperative effort between Texas and Louisiana, with no permanent federal funding.[2] Overall control policies and programs were agreed on by both states, with each state being responsible for development of its own shoreline. The final cost of the project was over $65 million. At a cost of $15 per acre-foot of water stored, this is well below the national average of $30 to $60 per acre-foot for such facilities.

The Toledo Bend Dam project was designed as a multipurpose facility.[3] The stated purposes were for hydroelectric power, water conservation, improvement of navigation, and recreation. The operation of Toledo Bend Reservoir is complicated by the need to satisfy these diverse and conflicting needs. A high stage is important for power generation, a low stage is important for flood control, and a near constant stage is important for recreation.

Although the Toledo Bend project was planned so that its cost would be largely met by the sale of hydroelectric power, the greatest long-term economic benefit could well be in the recreation area. This possibility was one of the reasons for the present study. Some 24 public sites for recreation facilities were set aside in the initial planning. Twelve were in Louisiana and 11 in Texas, with one site at the north end of the lake lying in both states. Louisiana has since added six more sites for a total of 18.[4] The sites on the Louisiana side were in various stages of development with none completed as of January 1, 1973. In addition, there were about 60 private commercial establishments or marinas in operation at the beginning of 1973 with more being built.

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[2] For a full account of this rather unusual cooperative endeavor, see: R. Douglas Morgan, "Toledo Bend—Example of Bi-State Cooperation." Paper prepared for ASCE Annual Meeting and National Meeting on Water Resources Engineering, New Orleans, La., 1969.

[3] See: Report on feasibility of Toledo Bend Reservoir on the Sabine River of Texas and Louisiana, prepared for the Sabine River authorities of Texas and Louisiana, Forest and Cotton, Inc., Consulting Engineers, Dallas, Texas.

Toledo Bend Reservoir, during its first few years, has enjoyed a reputation for being one of the "hottest" fishing lakes in the country, especially for bass. In witness to its popularity, the original estimate of 3 million visitor-days of use per year has been exceeded greatly. A study by the Louisiana Department of Highways indicates there are in excess of 4½ million visitations to the reservoir annually just on the Louisiana side.[5] Since many persons stay several days and some for as long as several weeks, it is not unreasonable to assume an annual usage of at last 10 million to 15 million visitor days.

Previous to the opening of Toledo Bend Reservoir, this part of Louisiana was considered economically depressed.[6] The two parishes bordering the reservoir area are Sabine and DeSoto. In 1970, 71.1 percent of the population of Sabine Parish was classified as rural. Mansfield, the largest town in DeSoto Parish, had a population of only 6,432 persons in 1970 and was ranked forty-seventh in size in the state. Many, the largest town in Sabine Parish, had only 3,112 people in 1970 and was ranked eighty-first of the urban places in the state. According to the reports of the 1970 U.S. Census, the median family income for DeSoto Parish and for Sabine Parish was $5,074 and $5,146, respectively, while that for the state as a whole was $7,530. Between 1960 and 1970, DeSoto Parish had a net outmigration of 16.1 percent for whites and 28.4 percent for Negroes and other races. The outmigration of the members of these races from Sabine Parish was 10.9 percent and 32.9 percent, respectively.[7] From the above description it can be seen that this part of Louisiana was an ideal one for a development program. At the same time that it was economically depressed it had the potential for a natural resource development.[8]

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[4] As of January 1, 1973, others were contemplated.

[5] *Toledo Bend Recreation Area Origin—Destination Study,* Traffic and Planning Section, Louisiana Department of Highways, 1971, p. 15.

[6] For a detailed study of the economic characteristics of the Toledo Bend area before the reservoir, see: *Toledo Bend Reservoir Development Program and Economic Feasibility of Major Tourist Complex,* Gulf South Research Institute, Baton Rouge, La., 1967, pp. 13-25.

[7] U.S. Bureau of the Census, Census of Population: 1970, Detailed Characteristics Final Report PC(1) -20, Louisiana.

[8] For a study of projected increase in ad valorem taxes, see: *Projected Ad Valorem Taxes Arising from the Development of the Toledo Bend Reservoir,* Division of Business and Economic Research, Louisiana Polytechnic Institute, Ruston, La., 1969.

Description of Toledo Bend Reservoir

Toledo Bend Reservoir is a 65-mile-long, man-made, fresh-water lake situated on the Louisiana-Texas border. It was formed by damming the Sabine River at a distance of 156.5 miles upriver from its discharge point into Sabine Lake, which in turn discharges into the Gulf of Mexico.

The reservoir itself is long and narrow with an average width of about 3 miles, but widens to about 6 miles where the pool extends up the courses of tributaries. The lake covers an area of 181,000 acres at its normal level of 172 feet above sea level. The depth of the main body of the lake ranges from about 84 feet in the old river channel at the base of the dam, to 10 or 12 feet at its upper end at Logansport, Louisiana. The average depth is about 60 feet. The reservoir holds some 4½ million acre-feet of water and has a shoreline of approximately 1,200 miles, making it the fifth largest man-made lake in the nation.

The dam site is located about 13 miles northeast of Wiergate, Texas, and approximately 18 miles west of Leesville, Louisiana. On the Texas side the reservoir lies mainly in Sabine and Shelby counties with a small portion in Newton County. On the Louisiana side it lies in Sabine and DeSoto parishes.

The reservoir is located within the Pine Forest Belt of East Texas and western Louisiana. The flooded areas were largely covered with timber; however, there were small areas devoted to agriculture and grazing. Use of the land for agriculture diminished as the timber industry developed. On the whole, the Sabine floodplain was relatively infertile and uninhabited. Of the total reservoir lands, about 56 percent or 101,600 acres lie in Louisiana and the balance of 44 percent or 80,000 acres in Texas.

Methodological Procedure

The approach of this study was an "on-site" survey in which data were obtained from persons engaging in recreation activity at Toledo Bend. A questionnaire was constructed utilizing questions of interest to the Louisiana Parks and Recreation Commission, the Louisiana Wild Life and Fisheries Commission, and the Louisiana Tourist Development Commission, as well as standard questions for studies of this type. This instrument was pretested and subsequently revised in early July of 1971. Data collection took place in July, August, and September of 1971 and at various times throughout the year until late spring of 1972.

The population universe for the study was defined as all persons who used the Louisiana side of Toledo Bend Reservoir and the immediately surrounding area for purposes of outdoor recreation. The "immediate area" was considered that area within one mile of any portion of the lake itself. "Outdoor recreation" was defined to include fishing, hunting, boating, hiking, swimming, camping, water skiing, picnicking, or sightseeing.

Interviewers were stationed at key access locations on different days of the week and at different seasons of the year. They were instructed to interview anyone who appeared to be using the area for recreation purposes.

Only one adult person per recreation group was interviewed. Strenuous efforts were made to get interviews from persons who fit a "head-of-household" description. Females were interviewed if there were no males in the group or if males in the group were not immediately available.

While the sampling procedure used was admittedly not random, it is felt that the size of the sample (N=605) and the wide variety of sites from which the interviews were obtained (a total of 52 different locations), as well as the different time periods, assure respresentativeness sufficient for making generalizations suitable for planning purposes.

In most cases interviews were administered face-to-face, with the interviewer asking the respondent questions and recording his replies. In those instances where respondents did not have time for an interview, they were given a questionnaire and a stamped preaddressed envelope. The names and addresses of the latter respondents were taken and a follow-up letter was sent 3 weeks afterward if no reply was received. Mailbacks accounted for only 42 of the 605 completed questionnaires.

The final number of completed interviews was, as noted, 605. Each interview represented a single party. (By party is meant those persons whom the interviewee designated as belonging to his group or party.) Of the interviewees, 544 were males and 61 were females; only four (one female) of the total were black. The smaller number of blacks appears to be the result of very few black people using Toledo Bend for recreation purposes. Almost all blacks seen were working at the various marinas rather than engaging in recreation.

Demographic Characteristics of Toledo Bend Users

Among the first questions which ordinarily arise when discussing a recreational facility are those which relate to the age, sex, education, occupation, etc., of the individual users of the facility. For this reason an effort was made to determine what may be termed the demographic characteristics of the recreationist population at Toledo Bend. Six major personal characteristics—occupation, age, sex, education, family income, and place of residence—were determined in the study.

Occupation

For purposes of analysis, occupations of family heads were classified according to the broad job categories used in the U.S. Census, with designations of "student," "military," and "retired" added. The findings are presented in Table 1. Comparisons are made of the sample population with the occupational distribution of white males 16 years and above for both Louisiana and the nation. It should be noted that, in

TABLE 1.—Occupations of Toledo Bend users in sample population

Occupation	% of total Toledo Bend sample		% of 1970 occupations of white males 16 and over*		% of total Toledo Bend sample, Louisiana residents only	
	Actual	Adjusted[1]	U.S.	La.	Actual	Adjusted[1]
Professional, technical, & kindred workers	11.1	13.4	14.6	11.7	11.2	13.6
Managers, officials, & proprietors	17.3	21.0	18.9	9.2	17.4	21.1
Clerical & kindred workers	4.5	5.4	7.5	6.7	5.1	5.0
Sales workers	7.8	9.4	6.1	6.2	7.8	9.4
Craftsmen, foremen, & kindred workers	14.9	18.0	20.8	21.7	14.5	17.6
Operatives & kindred workers	21.2	25.7	18.7	20.6	21.5	26.0
Service workers (includes household)	2.0	2.4	6.1	7.8	2.2	2.7
Laborers (includes farm)	3.8	4.6	7.9	11.9	3.9	4.7
Students	4.0				4.3	
Retired	7.6				6.5	
Military	2.6				3.1	
Other	1.8				1.6	
No information	1.5				1.8	
	N=605	N=499			N=489	

[1] Adjusted excludes students, retired, military, other, and no information.

*Source: Handbook of Labor Statistics, 1971, U.S. Department of Labor, Bureau of Labor Statistics, Washington, D.C.

interviewing, the tacit assumption was made that the male's occupation was the principal occupational classification for the family.

A glance at Table 1 confirms the fact that Toledo Bend recreationists tend to come from what may be termed the broad middle class strata. In this regard, it was expected that a slight over-representation among the more highly paid occupational categories would be found among Toledo Bend users. This expectation was based on the fact that upper economic level groups have more money to spend on recreation activities. This expectation was generally borne out by the data, particularly if a comparison is made of the adjusted percentages from each occupational group for the Louisiana-only portion of the sample with the percentages for Louisiana given by the U.S. Census. Professional, technical, and kindred workers were slightly over-represented, while managers, officials, and proprietors were greatly over-represented. The occurrence in the user sample of the latter was twice what would be expected judging from their occurrence in the population of Louisiana. However, comparison with the national patterns of occupational distribution shows upper classes were only slightly over-represented. Interestingly, clerical and kindred workers were slightly under-represented and sales workers over-represented by about one and one-half times as judged by comparison with Louisiana occupational data. The slight under-representation of craftsmen, foremen, and kindred workers was unexpected. Some researchers have found a curvilinear relationship to exist with regard to occupational prestige for the activity of fishing.[9] Since fishing is the principal activity for which Toledo Bend is noted, it was expected that the category of craftsmen, foremen, and kindred workers would be over-represented, but this was not the case. This finding seemed particularly unusual because the category of operatives and kindred workers showed a slight over-representation. As expected, service workers and laborers were under-represented, each of these occupational categories being represented by only about half the relative number they make up in the state's population.

Age and Sex

A breakdown of the total sample of Toledo Bend users by age and sex is presented in Table 2. Here all the members of a given group are included, not just the interviewee. The census age-sex composition for the white population of Louisiana is given for the sake of comparison. As expected, men were encountered more often among users of Toledo Bend than women; the surprising thing was that the difference was not greater. As can be seen in Table 2, the distributions for both males

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[9] Rabel J. Burdge, "The Occupational Analysis of Leisure: Status Occupational and Differential Leisure Behavior," unpublished paper presented at annual meeting of the American Sociological Association, New Orleans, La., 1972, p. 11.

TABLE 2.—Distribution of age and sex characteristics in sample population of Toledo Bend groups

Age (years)	Total sample	% of total sample	No. males	% of males	No. females	% of females	% of all La. Whites in age groups*
Under 5	151	5.1	81	4.7	70	5.7	8.7
5-13	572	19.5	330	19.3	242	19.7	18.6
14-17	268	9.1	170	10.0	98	8.0	8.0
18-24	314	10.7	174	10.2	140	11.4	12.2
25-34	488	16.6	274	16.0	214	17.4	12.6
35-44	481	16.4	271	15.9	210	17.1	11.5
45-54	395	13.5	238	13.9	157	12.8	11.1
55-64	177	6.0	116	6.8	61	5.0	8.8
65+	90	3.1	55	3.2	35	2.9	8.5
Total	2,936	100.0	1,709	100.0	1,227	100.0	100.0

*Source: U.S. Bureau of the Census, Census of Population: 1970, General, Social and Economic Characteristics, Final Report PC (1)—C 20 Louisiana.

and females throughout the total age range were very smiliar. There was no particular "lumping" at a given age classification among users by either sex.

Children under 5 were slightly under-represented in the user sample population when compared with the state percentages in this age group, but this is not surprising. Representation of those in the 5 through 24 age group was just about equal to the state figures. However, beginning with age 25 and extending to age 54 a slight over-representation was found among users as compared with the numbers in these age classes in the state. After age 55, the sample of users showed an under-representation when compared with the general state population, but considerable activity was evidenced by older persons. The findings of this study are consistent with those of previous studies.[10] As Table 3 indicates, there were 7.2 percent more males than females in the under 5 years of age class. Whether this difference represents a very early role differentiation the writers are not prepared to say, but this is a logical assumption. From 5 through 13 years, the male preponderance increased to 15.4 percent. From 14 through 17 years it was even higher, 26.8 percent. The difference was no doubt accounted for by the incidence of fathers or uncles or grandfathers taking their sons, nephews, or grandsons fishing, which is an expected role pattern. Additionally, there would be a greater tendency for a juvenile male friend of a youngster in this age range to be taken along with a group than for juvenile female friends to be included. The above differences in recreation group representation definitely indicate differential socialization of males and females insofar as outdoor recreation is concerned.

TABLE 3.—Age comparison of male and female Toledo Bend users in sample population

Age (years)	Total sample	No. males	% of males	No. females	% of females
Under 5	151	81	53.6	70	46.4
5-13	572	330	57.7	242	42.3
14-17	268	170	63.4	98	36.6
18-24	314	174	55.4	140	44.6
25-34	488	274	56.2	214	43.8
35-44	481	271	56.3	210	43.7
45-54	395	238	60.3	157	39.7
55-64	177	116	65.5	61	34.5
65+	90	55	61.1	35	38.9
Total	2,936	1,709		1,227	

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[10] Outdoor Recreation Resources Review Commission, *Participants in Outdoor Recreation: Factors Affecting Demand Among American Adults* (Washington, D.C.: U.S. Government Printing Office, 1962), p. 27. Aaron D. Johnson, R. A. Christiansen, and Hugh A. Johnson, *Vacationer Characteristics and Recreation Interests at 90 Wisconsin Resorts in 1967* (Madison: University of Wisconsin, Research Division, College of Agriculture & Life Sciences, Research Report 66).

In age group 18 through 24 years, males were over-represented by only 10.8 percent, in age group 25 through 34 by only 12.4 percent, and in age group 35 through 44 by only 12.6 percent. This drop in male dominance can be explained. These are the times when families have young children and when recreation as a family group is at its highest point. More will be said about this phenomena when makeup and characteristics of groups or parties are discussed.

In the 45 through 54 year age group, males predominated over females by 20.6 percent and in the 55 through 64 year range they predomianted by 31 percent. Above age 65 there was a tapering off of this sex differential down to 22.2 percent. It is at this stage of life, after the children are grown and away from home, when there seems to be a greater predominance of male-only groups at Toledo Bend. A possible explanation is that there is an increasing reluctance on the part of wives to suffer the physical discomforts of a fishing trip, coupled with a decline in interest in outdoor recreation since the children are no longer home. It should be stressed, however, that substantial proportions of women were present as Toledo Bend users in all age categories.

Education

Comparison of the educational attainments of persons in the Toledo Bend user sample population with white Louisiana residents age 25 and over yielded exepected results. Examination of Table 4 shows that the lower educational levels were under-represented and the upper levels were over-represented in the sample population. This finding was consistent with the findings of other studies.[11] The sample population frequencies were very close to the state frequencies.

The first two educational level groups (Table 4), less than 8 years and 8 years of schooling, were made up principally of Louisiana residents, 77.8 percent and 70.2 percent, respectively. These classes represented rather small sub-samples, 18 and 24 respondents, and this may account for their having been greatly under-represented as compared with the total state population. The 9 through 11 years of schooling group showed the highest percentage of Louisiana residents of any age category: 91.5 percent. It is not known whether this was the result of Louisiana having a higher percentage of persons than other states in this particular education class or whether the people in this class lacked the means to travel very far for their outdoor recreation. The latter seems feasible, however.

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[11] Outdoor Recreation Resources Review Commission, *Prospective Demand for Outdoor Recreation* (Washington, D.C., U.S. Government Printing Office, 1962), pp. 19-28. Outdoor Recreation Resources Review Commission, *Participants in Outdoor Recreation: Factors Affecting Demand Among American Adults* (Washington, D.C., U.S. Government Printing Office, 1962), p. 11. William R. Burth and Wiley D. Wenger, Jr., *The Social Characteristics of Participants in Three Styles of Family Camping,* U.S. Forest Service Research Paper PNW-48, 1967, p. 19.

TABLE 4.—Educational attainments of Toledo Bend users in sample population

Education in years	Total sample			Louisiana only			La. only as percent of category	Education of white La. residents 25 years & over**
	Number	Percent	Adjusted percent*	Number	Percent	Adjusted percent*		
Less than 8	18	3.0	3.0	14	2.9	2.9	77.8	22.5
8	24	4.0	4.1	19	3.9	4.0	79.2	8.3
9-11	59	9.6	10.0	54	11.0	11.3	91.5	19.2
12	258	42.6	43.7	210	42.9	43.9	81.4	28.9
13-15	100	16.5	16.9	75	15.3	15.7	75.0	10.3
16	81	13.4	13.7	61	12.5	12.8	75.3	6.5
Over 16	51	8.4	8.6	45	9.2	9.4	88.2	4.3
No information	14	2.3		11	2.2			
	N=605		N=591	N=489		N=478		

*Adjusted excludes no information category.

**Source: U.S. Bureau of the Census, Census of Population: 1970, General. Social and Economic Characteristics Final Report Pc (1) — C 20 Louisiana.

Louisiana high school graduates made up 81.4 percent of the high school (12 years) educational category. The occurrence of persons with only a high school education in the sample was about one and one-half times greater than would be expected from their relative presence in the state population.

The 13 through 15 years and 16 years of formal schooling groups contained about the same number of individuals, with three out of four of the persons in each group coming from Louisiana. The increase in the number of persons from outside the state in these educational attainment classes indicates a greater mobility of individuals with this level of education, which one would expect because of the association of higher income with educational attainment. These two educational groups were over-represented among Toledo Bend users by a factor of one and one-half and two, respectively. Louisiana residents made up 88.2 percent of the highest education category, over 16 years of schooling. The representation for this level of education in the Toledo Bend sample was twice its representation in the general population.

Family Income

Respondents were requested to give the total income of their immediate family. Distribution of respondents by family income is shown in Table 5. Family income is shown for white Louisiana residents for comparative purposes. In this regard, the income distribution for white Louisiana families rather than all Louisiana families was used since the four blacks in the sample were not used in the compilation of income data.

The percentage distributions for the various income classes of the white Toledo Bend user sample and for the Louisiana residents sub-sample of this group were very much alike. When these distributions are compared with the state distribution of white family income classes, it can readily be seen that persons with family incomes ranging from $1 to $8,000 were considerably under-represented among Toledo Bend users. By contrast, the percentage of white respondents in the sample population whose family incomes ranged from $8,000 to $10,000 was just about equal to the percentage of the state's white population in these income classes. Interestingly, among those persons claiming a family income of $10,000 and up, there was a marked over-representation among Toledo Bend users. As can be seen in Table 5, the percentages of upper income groups in the sample of users were almost twice what would be expected, judging in terms of their relative number in the state population as a whole.

The findings presented above are consistent with the findings of other researchers.[12] As family income increases there appears to be

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[12] Outdoor Recreation Resources Review Commission, *Participants in Outdoor Recreation: Factors Affecting Demand Among American Adults* (Washington, D.C., U.S. Government Printing Office, 1962), p. 27. Rex W. Cox and Jerome E. Johnson, *Outdoor Recreation Activities of North Dakota Residents* (Fargo, N.D., North Dakota State University, Dept. of Agricultural Economics, Agricultural Experiment Station, Agricultural Economics Report No. 72, 1972), p. 18.

TABLE 5.—Family income of white respondents and white Louisiana respondents compared with income of white Louisiana residents

Annual income (dollars)	Family income of white respondents				Family income of white La. residents*
	No. all respondents	No. La. respondents	% all respondents	% La. respondents	%
1- 999	1	1	0.2	0.2	3.1
1,000- 1,999	4	4	0.7	0.9	4.4
2,000- 2,999	4	3	0.7	0.6	4.9
3,000- 3,999	4	4	0.7	0.9	5.2
4,000- 4,999	9	6	1.5	1.3	5.5
5,000- 5,999	11	9	1.9	1.9	6.3
6,000- 6,999	21	14	3.6	3.0	6.9
7,000- 7,999	30	27	5.2	5.8	7.4
8,000- 8,999	38	33	6.5	7.1	7.8
9,000- 9,999	29	24	5.0	5.1	7.1
10,000-11,999	110	92	19.0	19.7	12.7
12,000-14,999	113	95	19.5	20.4	12.5
15,000-24,999	163	120	28.1	25.8	12.4
25,000+	43	34	7.4	7.3	3.8
Total	580	466	100.0	100.0	100.0

*Source: U.S. Bureau of the Census, Census of Population: 1970, General, Social and Economic Characteristics Final Report PC (1) — C 20 Louisiana, p. 175.

a definite increase in participation in outdoor recreation, up to a level of about $25,000. After this level of income is reached, there appears to be a decline in recreation activity of the type represented by Toledo Bend. The data from this study do not indicate such a decline clearly, but this may be because few people with large incomes were included in the sample, and also because the lower limit of the highest income category may not have been high enough to reflect the change in behavior. Camping and fishing are reported to be most popular in households of moderate and middle income. Since these are the major activities available at Toledo Bend, the findings can be said to support this pattern.

Residence

A question on size of place of residence was asked of only a relatively small sub-sample (167 persons) of the interviewees. This was because the question was not added until late in the study. Nevertheless, some insight can be obtained from the data gathered. Classifying place of residence according to the U.S. Census classification shed some light on the question of effect of residence on outdoor recreation at Toledo Bend.

Urban areas were over-represented in the sample Toledo Bend user population if a comparison is made with U.S. Census data for Louisiana for 1970 (Table 6). Such a comparison provides evidence that rural areas were very much under-represented among Toledo Bend users. Persons living in towns ranging in size from 2,500 to 25,000 were about equal in their representation in both the Toledo Bend sample and in the general population.

Persons from places ranging in size from 25,000 to 100,000 were considerably over-represented in the user sample, appearing in twice the number which would be expected from Census proportions. Users claiming residence in places of 100,000 population and above were not over-represented in as striking a fashion, but were present in a disproportionate number. It is likely that the advantages of increased income, education, and occupational opportunity, which many urban residents tend

TABLE 6.—Size of place of residence of respondents in Toledo Bend user sample and Louisiana sub-sample as compared with 1970 U.S. Census data for Louisiana

Size of place	Total sample		La. sample		La. census
of residence	Number	Percent	Number	Percent	(Percent)
2,500 or less (inc. farm)	22	13.2	13	11.7	33.9
2,500 to 25,000	34	20.4	24	21.6	21.0
25,000 to 100,000	45	27.0	29	26.1	11.2
100,000 and over	66	39.6	45	40.5	29.5
	(N=167)		(N=111)		

to have, were the important factors in their over-representation as Toledo Bend users.

The childhood residence of respondents yields strong circumstantial evidence for the idea that persons who enjoyed a rural youth will be more active participants in forms of outdoor recreation such as those available at Toledo Bend. More than 33 percent of the respondents said they grew up on a farm (see Table 7). Another 17.3 percent were from rural non-farm places. It may be difficult to ascertain what portion of the current state population is from a rural background, but it seems that certainly a larger part of the sample user population had a rural background than might have been expected from the state population generally.

TABLE 7.—Size of respondents' childhood place of residence

Size of place of residence	Number	Percent	Adjusted percent*
Farm	189	31.2	33.0
Rural non-farm	99	16.4	17.3
Less than 2,500	43	7.1	7.5
2,500-10,000	49	8.1	8.6
10,000-25,000	38	6.3	6.7
25,0000-50,000	38	6.3	6.7
50,000-100,000	40	6.6	7.0
100,000-250,000	40	6.6	7.0
250,000+	35	5.8	6.2
No information	34	5.6	
	(N=605)		(N=571)

*Adjusted excludes no information category.

Characteristics of Recreation Expeditions

Information regarding distance traveled, parish of residence, equipment carried, expenditures, and activities of recreationists at Toledo Bend should be of considerable interest to many persons and agencies. This section of the report is devoted to a summary of findings related to the characteristics of what has here been termed "recreation expeditions."

Distance Traveled

The distance people must travel to reach an area suitable for the recreation purposes they have in mind appears to exert a considerable influence on their outdoor recreation activity. Certainly the expectation would be a decreased frequency of usage as distance increases. Another factor which no doubt influences the relationship between recreation and distance is the increase in alternative recreation opportunities as distance from home to site increases. These alternatives are of two types. The first is an "intervening type," that is, a site located on or near the route which a person takes from his home to the first choice recreation area. The second class of alternative sites might be called "competitive," since travel in a different direction is involved. It is logical to assume that the likelihood of competition from either "intervening" or "competitive" alternatives increases as distance increases.

It was anticipated that, because of these factors, it would be possible to see zones of decreasing per capita usage as distance from Toledo Bend increased.

Table 8 shows the number of persons traveling various distances to get to Toledo Bend. (Note: In each case the respondent was asked to give the distance he had traveled to get to Toledo Bend. If he was unable to do so the distance was calculated from the respondent's place of residence.) For the most part the respondents were very knowledgeable of both the distance and the time necessary for their trips. Figure 1 shows the parish of residence of Louisianians in the sample. As can be seen, all the more urban areas were well represented. Figure 2 is a map of Louisiana with the parishes of residence of Toledo Bend users adjusted for density of population. The rates shown are in terms of respondents in the Toledo Bend sample per 100,000 population.

TABLE 8.—Distance traveled by respondents to get to Toledo Bend

Distance traveled (miles)	Number of persons	Percent
0 - 49	31	5.1
50 - 74	53	8.8
75 - 99	117	19.3
100 - 149	127	21.0
150 - 199	72	11.9
200 - 249	94	15.5
250 - 299	32	5.3
300 - 499	39	6.5
500+	40	6.6
Total	605	100.0

Table 9 gives the frequency of visits per year of respondents by the distance they traveled. First-time visitors were excluded to give a better picture of patterned or repetitive behavior. Figure 3 shows the zones of decreasing frequency of usage and graphically illustrates the data in Table 9. The median score of frequency of visits per year is given for each zone. As can be seen, there was a rather definite decrease in usage as distance from Toledo Bend increased.

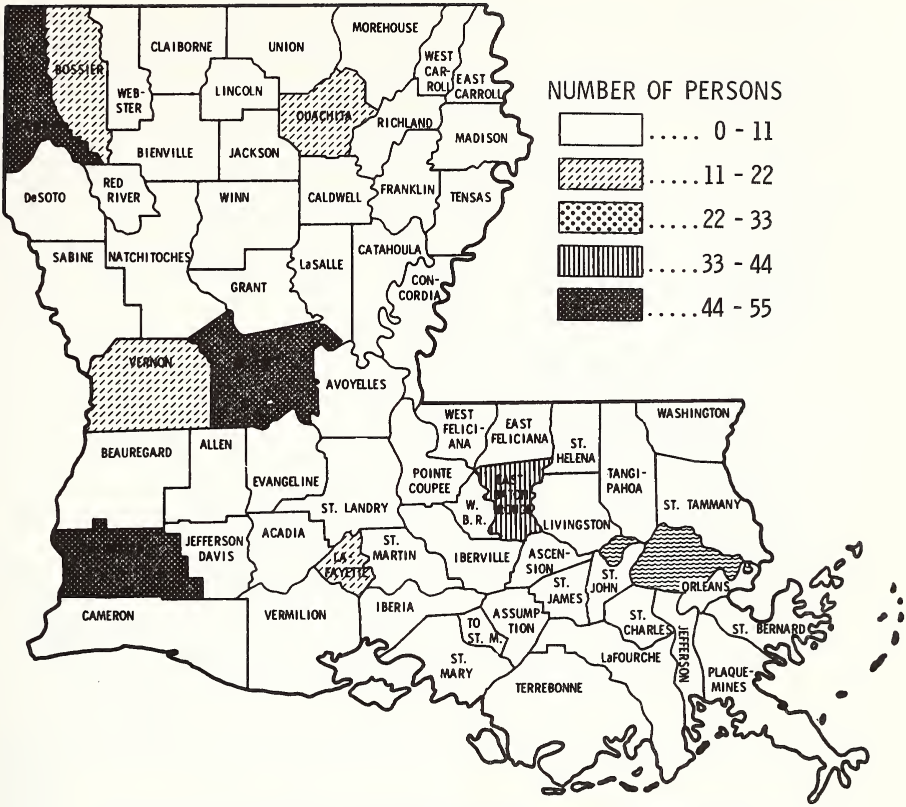

Figure 1.—Parish of residence of Louisiana respondents.

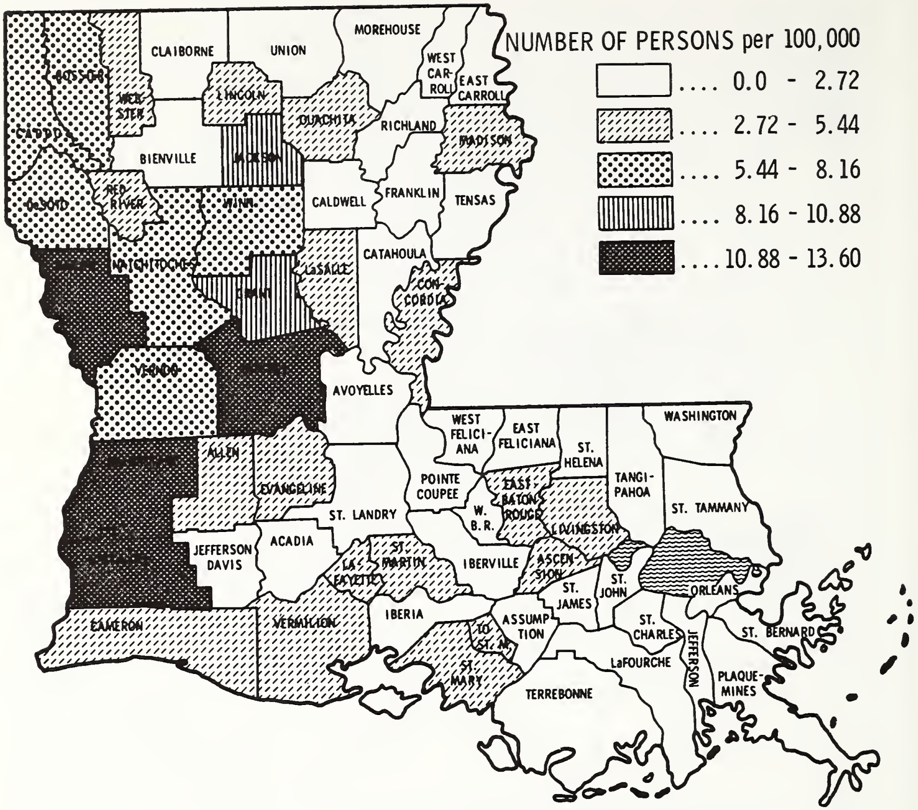

Figure 2.—Parish of residence of Louisiana respondents per 100,000 population.

TABLE 9.—Distance traveled to Toledo Bend and number of visits per year by respondents, excluding persons who were first-time users

Distance traveled (miles)	Number of visits per year						Total visits	Median number of visits per year
	1-4	5-9	10-14	15-19	20+	No response		
0- 49	4	1	2	2	17	4	30	30
50- 74	18	11	5	4	11	2	51	6
75- 99	20	22	13	6	45	5	111	13
100-149	32	34	15	5	28	0	114	8
150-199	34	12	3	2	3	0	54	4
200-249	41	20	5	1	5	1	73	4
250-299	15	3	0	0	2	1	21	2.5
300-499	16	2	1	0	0	0	19	2
500+	9	1	1	0	0	0	11	2

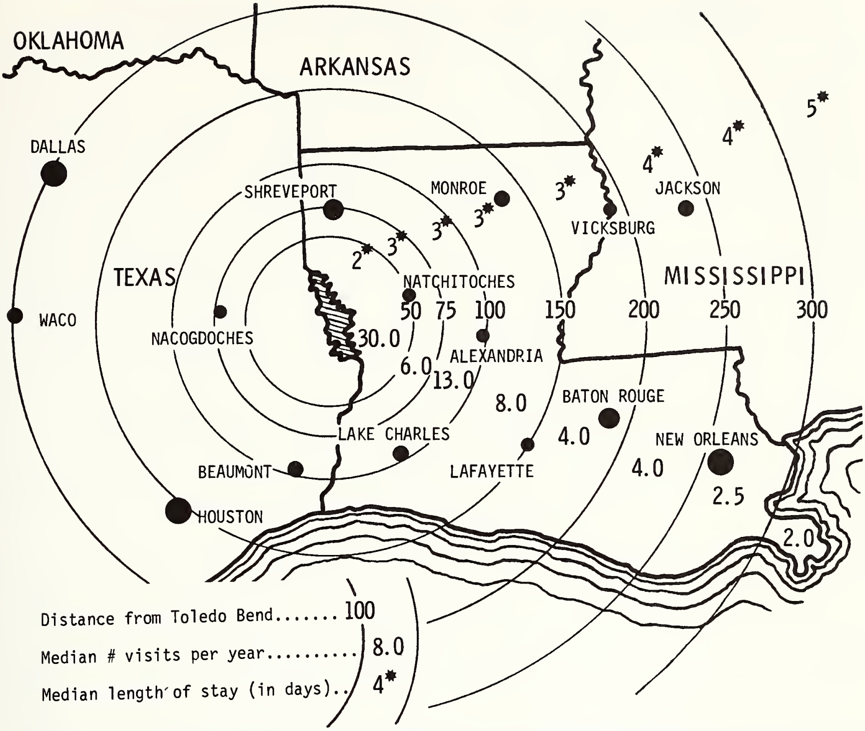

Figure 3.—Toledo Bend area, showing zones of decreasing frequency of visits.

Day of Arrival and Length of Stay

The most popular day of the week for arrival at Toledo Bend was Friday, with two of every five respondents arriving on this day. The next most popular day was Saturday, which accounted for one-fifth (22.5 percent) of all arrivals. The least popular days for getting to Toledo Bend were Tuesday and Wednesday, with 3 and 3.8 percent of the respondents appearing on these days. Table 10 shows the number and percentage of interviewees arriving on a given day of the week.

Table 11 indicates how many days persons said they stayed or would stay at Toledo Bend. The number of days included the day of arrival as well as the day of departure. The most frequent time period was a stay of 3 days, with 30.4 percent of the persons interviewed indicating they stayed for this length of time. The typical pattern seemed to be for a group to arrive on Friday afternoon and depart on Sunday afternoon. The next most popular stay period was 4 days. This finding is apparently related to Monday holidays. The inclusion of the Labor Day and Easter weekends in the sampling probably had some effect here.

TABLE 10.—Respondents' day of arrival at Toledo Bend

Day of arrival	Number of groups	Percent
Sunday	49	8.1
Monday	40	6.6
Tuesday	18	3.0
Wednesday	23	3.8
Thursday	63	10.4
Friday	238	39.3
Saturday	136	22.5
No response	38	6.3
Total	605	100.0

TABLE 11.—Respondents' length of stay at Toledo Bend

Number of days*	Number of groups	Percent
1	50	8.3
2	89	14.7
3	184	30.4
4	135	22.3
5	40	6.6
6	20	3.3
7	24	4.0
8	14	2.3
9	7	1.2
10-20	24	4.0
21+	11	1.7
No response	7	1.2
Total	605	100.0

*Includes day of arrival and day of departure.

It was noted that a number of retired or semi-retired people had begun to spend periods of several weeks or longer at Toledo Bend. Many of these persons were from Louisiana, but others were from out-of-state and stopped off at Toledo Bend in either the fall or spring as they "migrated" from North to South and back again. Provision of facilities for such groups might be a means for marina owners to increase business at these non-peak times of the year.

Nature of Trip

Most people, as shown in Table 12, indicated the nature of their Toledo Bend outing as a weekend, overnight, or holiday excursion. One out of five of the interviewees, approximately 22 percent, indicated they were on a vacation of some kind. About 7 percent of these indicated they were on their major annual vacation, while another 15 percent described their visit as one of several shorter vacations they took during

TABLE 12.—Nature of trips as reported by Toledo Bend recreationists

Nature of trip	Number of groups	Percent
Major annual vacation	43	7.1
One of several shorter vacations	93	15.4
Weekend or overnight trip	258	42.6
Day-off trip	49	8.1
Holiday outing	123	20.3
Combined business and pleasure	5	.8
Combined visit to relatives and friends	18	3.0
Live or work at Toledo Bend	4	.7
Retired (spent frequent long stays)	6	1.0
Not specified	6	1.0
Total	605	100.0

the year. The remainder of the persons questioned were on a combined business and pleasure trip or lived or worked at Toledo Bend.

Type of Accommodations Used

Of the 548 interviewees who said that they had stayed more than one day at Toledo Bend, only 39, or about 7 percent, reported they had not stayed at a developed campsite or marina. A total of 558 persons indicated what type of accommodations their groups had used. Of these, 149, or 26.8 percent, said they had stayed in a travel trailer. Tents were the second most frequently used type of housing accommodation, with 116, or 20.6 percent, of the interviewees utilizing this type of facility (see Table 13).

TABLE 13.—Type of accommodations used by Toledo Bend recreationists

Type of accommodation	Owned by interviewee	Owned by someone in group	Borrowed from relative or friend	Rented	Other	No response	Total
Permanent residence on or near lake	11	6	2	4	2		25
Motel				10			10
Cabin or cottage	1	2	1	39		1	44
Permanently located house trailer	24	9	6	40	1	2	82
Travel trailer	118	10	12	8		1	149
Tent trailer	39	4	2	4			49
Truck/van camper	65	9	2	2			78
Tent	99	8	8	1			116
Other	3			1	1		5
Total	360	48	33	109	4	4	558

Only about 18 percent of all persons interviewed indicated that they had rented their accommodations. Interestingly, about 35 percent reported the accommodations they used were permanently located at Toledo Bend. In this regard, there is a widespread practice by marina owners of leasing trailer space on a relatively permanent basis. The recreationist places his house trailer or travel trailer on a leased site and thus has what amounts to a vacation home with all needed utilities and hookups. Access to the lake and availability of bait and other supplies, as well as constant surveillance of his property, are other advantages of this type of arrangement.

Boats and Motors Transported to Toledo Bend

It was found that 64.5 percent (two-thirds) of all interviewees reported the presence of one or more boats in their group. Interestingly, almost 7 percent reported that two or more boats were brought by their parties. However, 213 (35.2 percent) of the total reported that no one in their group had brought a boat to Toledo Bend (see Table 14).

Table 15 includes a list of the types of boats used by the recreationists interviewed at Toledo Bend. Of a total of 445 boats brought by recreationists, 149 or 33.5 percent were aluminum jon-boats (commonly called "bateaux" or "flats") or skiffs. About one-third (31.5 percent) were bass-type plastic boats over 14 feet long, while 15.1 percent were bass-type rigs of 14 feet or less. Most of the remainder (17.5 percent) were ski-type boats 14 feet or over. A few boats (2.5 percent) were of other

TABLE 14.—Number of boats brought per group to Toledo Bend

Number of boats brought per group	Number of groups	Percent of all groups	Total number of boats
One	349	57.8	349
Two	32	5.3	64
Three or more	8	1.3	32
No boat in group	213	35.1	
No response	3	0.5	
Total	605	100.0	445

TABLE 15.—Types of boats used by Toledo Bend recreationists

Type of boat	Number of boats	Percent of all boats
Aluminum jon-boat or skiff	149	33.5
Bass rig (14 ft. or less)	67	15.1
Bass rig (over 14 ft.)	140	31.5
Ski rig (14 ft. or more)	78	17.5
Other or not specified	11	2.4
Total	445	100.0

types or not specified. The large majority of boats brought to Toledo Bend were types which represent a considerable investment of money.

As might be expected, the number of persons who brought outboard motors with them to Toledo Bend was quite large. In fact only 82 persons, or 13.6 percent of those interviewed, said no one in their group had brought a motor. Table 16 shows the number and percentage of recreationist groups that had one, two, or three or more motors. Table 17 shows how the total of 591 motors brought were distributed according to size.

TABLE 16.—Number of outboard motors brought to Toledo Bend, per group

Number of motors in group	Number of groups	Percent of all groups	Total number of motors
1	459	75.8	459
2	43	7.1	86
3+	12	2.0	46
None	82	13.6	
No response	9	1.5	
Total	605	100.0	591

TABLE 17.—Sizes of motors used by Toledo Bend recreationists

Size of motor	Number of motors	Percent of all motors
Less than 5 hp.	24	4.0
5 - 10 hp.	198	33.5
11 - 25 hp.	103	17.5
26 - 50 hp.	154	26.0
50+ hp.	99	16.8
Inboard or I/O	3	0.5
Not specified	10	1.7
Total	591	100.0

Recreation Activities

The principal activity engaged in by recreationists at Toledo Bend was fishing. Only 30 persons, approximately 5 percent of those interviewed, reported they did not fish. In many cases such activities as camping and boating were engaged in, but as necessary activities in order to fish rather than being an end in themselves.

Of the 575 persons reporting they were at Toledo Bend to fish, 186 reported that they fished exclusively for bass. This represented about one-third (31 percent) of all persons interviewed. Another 20 individuals fished for bass as well as for bream, while an additional 23 reported fishing for both bass and crappie (sac-a-lait).

Only 36 persons, about 6 percent of those interviewed, claimed to be exclusively bream fishermen. Another 13 persons reported they confined their fishing to bream and crappie. Those fishing only for crappie numbered 32, or about 5 percent of those interviewed.

By far the largest category of fishing recreationists consisted of those who engaged in "mixed" fishing. Recreationists were placed in this category if they said they were not concentrating on trying to catch a particular type of fish but were fishing for whatever happened to be biting. This class included 265 persons, almost 44 percent of all those questioned (see Table 18).

TABLE 18.—Principal types of fish sought by Toledo Bend recreationists*

Principal types of fish sought	Respondents	
	Number	Percent
Bass only	186	30.7
Bass and bream	20	3.3
Bass and crappie	23	3.8
Bream only	36	5.9
Bream and crappie	13	2.1
Crappie only	32	5.3
Mixed	265	43.8
Did not fish	30	5.0

*Based on a total of 575 fishermen.

Other water-related activities were participated in, but much less frequently than fishing. Swimming was engaged in by at least one member of approximately 19 percent of the groups interviewed and skiing was participated in by someone in approximately 10 percent of the groups interviewed. Most of those who swam were children; very few adults took part in this activity. Boating for pleasure was reported by 13.5 percent of the interviewees.

An indication of why people come to Toledo Bend may be inferred from responses given to the following question: "What in your opinion are the major reasons for people coming to Toledo Bend?" Ninety-two percent of all persons interviewed said fishing was the major reason people visited Toledo Bend. However, 18 percent mentioned camping and 13 percent mentioned water skiing or swimming. Thirty-one percent indicated they thought people came to Toledo Bend for a change of pace, e.g., for rest or relaxation. An unexpected finding was that slightly more than 11 percent of the interviewees felt that people came to Toledo Bend for an aesthetic experience, i.e., to "get outdoors," and because the lake was large and attractive.

Expenditures for Toledo Bend Expeditions

A total of 431 individuals provided information suitable for estimating the amount spent per man-day of use by recreationists at Toledo Bend. This was determined to be $5.76 per person per day. However, for certain reasons this figure is considered low. First, most people consistently underestimate their expenses. Items are purchased and then forgotten, and more of such things as bait, ice, and other supplies are used than is realized. Second, many of the persons who maintained travel or house trailers at Toledo Bend did not include the cost of the lease or the cost of the trailer as part of their trip expense.

The authors of a previous study conducted by the Louisiana Department of Highways[13] estimated the average daily expenditure per person at Toledo Bend by Louisiana residents to be $4.83, while that for out-of-state residents was $4.56. This finding is contrary to those of this study, which determined Louisiana residents (341 cases) to have an average expenditure per man-day of $4.70 and out-of-state residents (90 cases) $9.78—more than twice the daily expenditure of Louisiana residents. There were some reasons for the higher expenditures by out-of-state visitors. First, the distances traveled tended to be greater, thereby representing greater transportation costs. Second, many more of the Louisiana residents owned their own accommodations, whereas visitors rented much of their equipment and their accommodations (see Table 19).

TABLE 19.—Ownership vs. rental of accommodations by Louisiana and non-Louisiana residents

Residence	Accommodations: Own	Accommodations: Rent	No. of persons
Louisiana	359	80	439
Out-of-state	78	30	108
Total	437	110	547

Table 20 shows the total trip cost as reported by the interviewees. Over half (55.1 percent) of those interviewed said they spent $49 or less. Approximately four of every five respondents reportedly spent less than $100 for their trip. The remainder of those reporting spent between $100 and $500. No one reported spending over $500. As shown in Table 21, almost three of every four persons said the expense incurred was typical of the amount they usually spent for a trip to Toledo Bend.

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[13] *Toledo Bend Recreation Area Origin-Destination Study,* Traffic and Planning Section, Louisiana Department of Highways, 1971, p. 18.

TABLE 20.—Trip costs reported by Toledo Bend recreationists

Cost in dollars	Number of persons	Percent
Under 10	31	5.1
10 - 19	64	10.6
20 - 29	102	16.9
30 - 39	82	13.6
40 - 49	54	8.9
50 - 74	116	19.2
75 - 99	27	4.5
100 - 500	113	18.7
No response	16	2.5
Total	605	100.0

TABLE 21.—Responses to question on whether costs reported were typical for a trip to Toledo Bend

Response	Number of persons	Percent
Yes	446	73.7
No, usually more	23	3.8
No, usually less	51	8.4
Don't know	50	8.3
No response	35	5.8
Total	605	100.0

Group Nature of Recreation Experience

Sociability has been suggested as a "cause" of participation in outdoor recreation. Sociability, as used here, refers to the inclination which people have to associate with others for the sheer pleasure of interaction, with no thought of practical aims or for other serious purposes.[14] Most outdoor recreation takes place with at least two people together. The recreational experience, in this sense, is very much a social experience—or at least it is experienced in a social context. This study was not explicitly designed to measure sociability in terms of a person's activity or participation at Toledo Bend, but it was felt that an exploratory analysis of group structures along certain salient dimensions might yield interesting information. Also, such an analysis could well generate questions for further investigation.

Size of Party

Tables 22 and 23 indicate the "groupness" of recreational activity at Toledo Bend. In Table 22 it can be seen that group or party sizes varied considerably. (The boundaries of the group or party were set by the interviewee—any persons identified by him as belonging to the party were included.) Only 10 persons, or 1.7 percent of the sample population, said they were alone. Two-person parties were the modal size, with 146, or 24.1 percent of the respondents, indicating that one other person was in their party. The size of groups ranged up to 30 persons, but most groups did not exceed six persons. The median size of Toledo Bend parties was four persons. Interestingly, many of the larger groups were in the nature of family reunions. Family units from various localities met at Toledo Bend, particularly if it was more or less centrally located, to visit and enjoy together the activities available there.

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[14] George A. Theodorson and Achillles G. Theodorson, *A Modern Dictionary of Sociology* (New York, N.Y., Thomas Y. Crowell Co., 1969), p. 368.

Types of Groups

In Table 23 recreation parties are characterized according to their nature. These data show that for the Toledo Bend sample, recreation is commonly a family affair. Families made up of a husband and wife,

TABLE 22.—Sizes of groups of Toledo Bend users

No. of persons in group	Frequency of occurrence	Percent
1	10	1.7
2	146	24.1
3	73	12.1
4	86	14.2
5	80	13.2
6	62	10.3
7	34	5.6
8	26	4.3
9	20	3.3
10	20	3.3
11-15	39	6.5
16-30	9	1.4
Total	605	100.0

TABLE 23.—Characteristics of types of recreationist groups at Toledo Bend

Type of group	Number	Percent
Single family with no children	88	14.5
Single family with children	146	24.1
Two or more families	186	30.7
Family plus friends or relatives	76	12.6
Group of friends	78	12.9
One person alone	10	1.7
Organized group	1	.2
Other	18	3.0
No information	2	.3
Total	605	100.0

with or without children, comprised 38.6 percent, or 234, of the 605 sample groups. One hundred eighty-six parties (30.7 percent) were composed of two or more families, while 76 parties (12.6 percent) were composed of a single family plus one or more friends or relatives. Even in the "other" category (18 parties, 3 percent of the total), groups were composed of some combination of relatives or in-laws which could not be accurately assigned to one of the above classifications. The overall picture shows that 85 percent of the respondents were engaging in recreation in a "family type" atmosphere, that is, with other persons who were related to them.

Users' Opinions and Preferences Regarding Toledo Bend Facilities

A major objective of this study was to determine the feelings and preferences of users of Toledo Bend regarding certain aspects of this facility. Their responses to questions relating to this objective are summarized in the discussion which follows.

Opinions Regarding Toledo Bend as a Tourist Attraction

Almost all interviewees, some 598, expressed an opinion when asked if they thought Toledo Bend served as an important tourist attraction. Of this number, only 16 persons, or 2.6 percent, expressed the opinion that Toledo Bend held no particular appeal to tourists. The remaining 582 persons felt that Toledo Bend was attractive to visitors and gave varying reasons for their feelings. Over half these respondents (55.2 percent) were convinced that fishing was the reason tourists liked Toledo Bend. They noted that Toledo Bend had a nationwide reputation, especially for its bass fishing. Other reasons cited for the attraction of Toledo Bend were the growing demand for outdoor recreation, the increasing popularity of camping, the large size and beauty of the lake, and the fact that it could be used year-round. All in all, the overwhelming opinion was that Toledo Bend holds a strong attraction for local as well as out-of-state tourists (see Table 24).

TABLE 24.—Users' opinions regarding Toledo Bend as a tourist attraction

Opinion expressed	Number	Percent
No, it is not attractive to tourists	16	2.6
Yes, because of fishing	329	55.2
Yes, because of its size, opportunity for recreation, etc.	198	33.0
Yes, no reason given	55	9.2
Total	598	100.0

Opinions Regarding Facilities Available at Specific Toledo Bend Sites

After determining the opinion of interviewees regarding Toledo Bend as a tourist attraction, it was considered relevant to question them about things they felt could stand reasonable improvement at the particular site where they were staying.[15] Only one of every five persons (20.2 percent) responding indicated satisfaction with things as they were. Almost half (45 percent) of the individuals responding to this question mentioned roads as the most needed improvement regarding the site they were using. About half of those interviewed were dissatisfied with existing boat launches or ramps and with boat docks. The quality of restrooms was singled out as a needed improvement by almost 18 percent of those responding, and approximately 12 percent of the users questioned felt campsites could be improved by leveling and by the installation of electricity, sewer, and water hookups. Other improvements felt desirable were landscaping, cleaning and upkeep of grounds, tables, barbecue pits, trash receptacles, recreation facilities for children, additional or improved rental housing, and area services such as grocery stores, laundries, and telephones.

The above findings, outlined in Table 25, should be of interest to marina owners and operators. Most items, except roads, appear to be things which can be improved without exceptionally high expense.

TABLE 25.—Toledo Bend users' assessment of needed improvements at the particular sites at which they stayed

Improvements needed	Number[1]	Percent
None	118	20.2
Roads	260	44.6
Boat launches, ramps, & docks	127	21.8
Restrooms, showers	104	17.8
Campsite improvement—(level, electricity, sewage, water)	69	11.8
Grounds improvement—(landscape, cleaning, upkeep)	58	10.0
Housing	33	6.1
Area conveniences (grocery store, laundry, phone)	30	5.2
Recreational facilities for children	25	4.3
Tables, BBQ pits, trash receptacles	20	3.4
Other	43	7.4
Total		152.6*

[1] Base was 583 persons.

*Totals more than 100 percent because many people listed more than one thing.

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[15] For a detailed description of marinas and marina owner characteristics at Toledo Bend, see: *An Analysis of Louisiana Marina Owner Characteristics at Toledo Bend Reservoir,* unpublished Master's thesis by Paul J. Jastram, Louisiana State University, 1972.

Opinions Regarding the Toledo Bend Development as a Whole

The opinions of users were sought regarding a second distinct development aspect of Toledo Bend—improvement of the reservoir area as a whole. Each person interviewed was asked to respond to the following query: "Thinking in terms of the whole Toledo Bend development, do you feel certain things could be improved?"

Quite a large number of possible improvements were mentioned. However, a considerable number of the interviewees (17.2 percent) felt that facilities and opportunities for recreation at Toledo Bend were at least adequate and improvements were not especially needed. One can speculate that these individuals were not especially anxious to get more people on the lake, or desired to retain and protect the more or less natural look of Toledo Bend.

Most frequently mentioned as needed improvements for the overall area were "more state parks, more picnic areas, more boat launch ramps, and more campgrounds." These items were mentioned by at least one-fourth of all persons interviewed (see Table 26).

The provision of more adequate roads, including improved maintenance of existing roads, also ranked high as a suggested improvement. The need for more road signs was also mentioned.

Many persons were greatly concerned with increasing the safety of boating and fishing on the lake. In fact, one of every five persons suggested such measures as increased policing of the lake, enforcement of rules of safe boat operation, better navigation aids such as buoys or markers, clearing of unsafe stumps, and increasing the number of channels or boat lanes in the lake.

A number of people desired an increase in area services. For example, 14.2 percent of the interviewees felt the addition of grocery stores, restaurants, and laundromats would be most desirable. Almost an equal number (13.8 percent) felt that facilities such as hookups for campers, including access to electricty, water, and sewage lines, should be expanded.

There were also a considerable number of persons (11 percent) who felt more swimming areas or beaches, and more recreation areas or activities for children, young adults, and families, would be a great overall improvement.

Several other proposals for further developments were put forward by the people interviewed. One proposal was to upgrade the facilities through a systematic program for making tables, barbecue pits, and trash cans available to users. It was felt that a program of active maintenance, prompted by state inspection, would insure the upkeep of grounds and facilities.

Other ideas mentioned included the provision of additional motels and rental cabins, active pollution control programs, and a zoning plan for construction on the lake shore. Several persons felt the water level in the lake should be kept as near constant as possible, and that enforce-

TABLE 26.—Users' opinions regarding needed improvements for the Toledo Bend development as a whole

Needed improvements	Number	Percent
None—happy with it as it is	103	17.2
More state parks, more campgrounds, more picnic areas, more boat launch ramps	153	25.5
Roads	135	22.5
Increased safety and policing of lake, better navigation aids, clearing of stumps and channels	117	19.5
Better bathrooms, showers, and toilet facilities	56	9.3
More camper hookups (electricity, water, sewage, etc.)	83	13.8
More swimming areas, recreation areas, and activities for children, young adults, and families	66	11.0
Telephones	36	6.0
More grocery stores, restaurants, laundromats	85	14.2
Campgrounds improvement through better maintenance and provision of tables, BBQ pits, trashcans, etc.	31	5.2
More cabins or motels	19	3.2
Pollution control programs	13	2.2
Enforce good game management practice	14	2.3
Maintain water levels in lake	11	1.8
Zoning plan for shore construction	8	1.3
Clearing and zoning of water's edge	5	0.8
Other	34	5.7
No opinion or do not know	53	8.8
Total	1,022*	170.3**

*Base was 600; total is higher because many persons listed more than one needed improvement.

**Totals more than 100 percent because many persons listed more than one needed improvement.

ment of game laws and good game management practices should be followed. One suggestion was for clearance around the edge of the lake to provide access to many more miles of shoreline.

A follow-up question to the query on needed improvements was asked: "If money were available, what additions, improvements, or developments would you personally like to see at Toledo Bend in the future?" Responses to this question were much the same as to the first question, with one difference. This was the increased percentage of persons who suggested more state parks, more campgrounds, more picnic areas, and more boat launch ramps. The latter apparently represent high priorities in the eyes of the user public.

Preferences Regarding Control of Toledo Bend Facilities

Five hundred and ninety-six persons responded to a question concerning their preference for public versus private control and operation of Toledo Bend facilities. Slightly over half (56 percent) felt that a combination of publicly owned and operated and privately owned and operated facilities would be the best arrangement. However, over one-fourth (27 percent) preferred privately operated facilities and 15 percent preferred publicly controlled and operated facilities.

Reasons cited by persons favoring public or private facilities are worthy of note. Those favoring public facilities felt they were more likely to be better built and maintained than private facilities, particularly roads, bathrooms, and boat ramps. It was also conceived that public facilities would be less expensive and more accessible to the general public.

Those persons who preferred privately operated and controlled facilities felt that private ownership resulted in better service and offerings. Private ownership was also said to make for a wider range of facilities and services and a better class of clientele. There was a tendency for those preferring private operation to say they were ideologically in favor of private enterprise.

Those who favored a combination of public and private facilities at Toledo Bend cited many of the same reasons given by those favoring exclusively private or public facilities. It was felt by some that competition between public and private facilities was good in that it insured a wide range of services with people being able to choose the level of service they wished. Additionally it was felt that prices would be kept down since monopoly by any group would be prevented. Many people indicated they felt the state had an obligation to provide at least minimum recreation facilities for its citizens.

Only 13 persons, or about 2 percent, said it did not matter to them who controlled facilities at Toledo Bend.

Opinions Regarding Funding Sources for Toledo Bend Type Developments

A project the size of Toledo Bend Reservoir requires large investments of capital and is normally underwritten by state or federal government agencies. For this reason a question was asked to determine the feelings of users about funding sources for facilities or developments such as Toledo Bend Reservoir.

The majority of interviewees felt that the state, either alone or in concert with local and federal governments, had the principal responsibility for support of such projects as Toledo Bend (Table 27). The argument for state funding was that this was the best way to assure state control of the project. Somewhat surprisingly, many persons who felt the national government should pay all or part of the expense of pro-

TABLE 27.—Funding source preferences for Toledo Bend type developments as expressed by Toledo Bend users

Preferred funding source	Number	Percent
Local government	23	3.7
State government	194	32.2
National government	54	9.0
Local and state	41	6.8
State and national	143	23.8
Local, state and national	66	11.0
Undecided	41	6.8
Government should not pay	21	3.5
Other	19	3.2
Total	602	100.0

jects such as Toledo Bend still felt quite strongly in favor of state control of such developments. Only 3.5 percent of the respondents felt all government money should be kept out of such projects. Persons who expressed this sentiment did not offer an alternative source of funding; however, some suggestions were made to the effect that utility companies and other users could be charged fees sufficient for financing the development. It seems that Toledo Bend clients were convinced that government funding was required for such a development, but they preferred state control and management.

Conclusions

This study was undertaken to obtain benchmark information on the characteristics, recreation usage patterns, and preferences of users of Toledo Bend, a recently developed large fresh-water reservoir-lake located between Louisiana and Texas. Major findings or conclusions derived from the study are presented below.

Occupational distribution of users in comparison with occupational distribution of the general population of the state:

1. Professional, technical, and kindred workers were slightly over-represented.
2. Managers, officials, and proprietors were present in twice the numbers expected.
3. Clerical and kindred workers were slightly under-represented.
4. Sales workers were slightly over-represented.
5. Craftsmen, foremen, and kindred workers were slightly under-represented.
6. Operatives and kindred workers were slightly over-represented.
7. Service workers and laborers were represented by only about half of their expected numbers.

The overall conclusion reached from an analysis of occupational distribution of users is that a certain degree of affluence and a certain sophistication in terms of outdoor recreation is characteristic of Toledo Bend users.

Demographic characteristics of users in comparison with the general population of the state:

1. Urban residents were over-represented and rural residents were under-represented.

2. Both the very young and the very old were under-represented.

3. Persons from 25 to age 54 were slightly over-represented.

4. Persons with lower levels of education were under-represented while those with upper levels of education were over-represented.

5. Lower income groups (family income under $8,000) were considerably under-represented in the sample population, while family incomes in the $8,000 to $10,000 range were represented in expected numbers. Persons with a family income above $10,000 were represented in twice the numbers expected.

6. Men predominated among Toledo Bend users, but not to the degree expected.

7. The childhood residence of 50 percent of all respondents was either a farm (33 percent) or a rural non-farm setting.

Characteristics of visits to Toledo Bend for recreation:

1. Distance traveled to reach Toledo Bend had a significant effect on use of the reservoir. There was a strong inverse relationship between increasing distance and frequency of visits and a positive relationship between distance and length of time spent at Toledo Bend.

2. Two out of every five users arrived on a Friday, and one out of five arrived on a Saturday.

3. The most frequent length of stay was 3 days, with almost one-third of all users staying this length of time. A stay of 4 days was also quite popular.

4. Most users came to Toledo Bend for a weekend or holiday outing. Twenty-two percent of the users questioned indicated they were on a vacation of some kind.

5. Users staying overnight were most likely to stay in a travel trailer or tent they brought with them; however, one-third reported the accommodations they used were permanently located at Toledo Bend, such as privately owned house trailers on leased sites or rented cabins.

Characteristcis of recreation activities engaged in by users:

1. Two-thirds of the user groups interviewed brought a boat to Toledo Bend. About 7 percent of these groups brought two or more boats.

2. Almost eight out of nine groups brought an outboard motor; one-fourth of the groups brought two or more motors.

3. The most popular recreation activity engaged in at Toledo Bend was fishing, with only 5 percent of the users reporting they did not fish. Almost half of all fishermen engaged in "mixed" fishing; the remainder specialized primarily in bass fishing.

4. At least one person in every fifth user party went swimming and at least one person in every tenth user party participated in water skiing.

5. The average expenditure per man-day at Toledo Bend was $5.76. Louisiana residents reported spending $4.70 per day per person while out-of-state residents reported spending $9.78 per person per day.

6. Over half the persons using Toledo Bend reported spending around $50 for a trip.

Selected opinions and preferences of users of Toledo Bend:

1. There was an overwhelming opinion that people came to Toledo Bend primarily to fish.

2. Users felt improvements or developments should include more state parks, more boat launch ramps, more and better roads, improved maintenance of facilities, improvement of boating safety, and more area services such as restaurants and grocery stores.

3. A majority opinion was that a combination of both publicly and privately owned and operated facilities was necessary at Toledo Bend.

4. A majority felt that the state, either alone or with local and national government help, should be responsible for funding projects such as Toledo Bend.

5. There was an overwhelming belief that the state should have control of and administrative responsibility for Toledo Bend.

Sociability characteristics of Toledo Bend users:

1. Virtually all of the users were members of groups of two or more people; less than 2 percent of all persons interviewed reported that they were alone.

2. Two-person parties were the modal size, with about one of every four groups composed of only two people.

3. The median party size was four people.

4. Many large groups were in the nature of family reunions. In fact, of all those interviewed, 85 percent were engaging in recreation in a "family type" atmosphere, that is, with other persons who were related to them.

At least two important implications may be derived from the above findings. First, it is clear that Toledo Bend, already an important recreation area for the state, can play an increasing role in satisfying the growing demand for recreation facilities. The second implication derives from the fact that a certain type of person tends to predominate among the users of Toledo Bend; these users tend to be better educated, more affluent, more mobile, and more urban.

All in all, a knowledge of the characteristics of use and users of Toledo Bend serves to provide a sound basis for planning future recreational developments of this type within the state.

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Effects of Nitrogen, Population and Hybrid on the Yield and Quality of Irrigated Corn for Silage on Providence Soil

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Effects of Nitrogen, Population, and Hybrid On the Yield and Quality of Irrigated Corn For Silage on Providence Soil

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INTRODUCTION AND OBJECTIVES

Results of silage feeding trials conducted throughout the United States continue to support the old adage that "corn is king of the silages." Most corn production research, however, has been directed toward the development of production practices that maximize grain yield. The assumption has been that these same practices will also maximize silage yield and feeding value. Obviously, grain yield is extremely important since the grain component is the principal source of digestible energy in corn silage. However, since the entire plant is usually ensiled, the high-fiber plant components (leaves, stems, husks, and cobs) should make additional contributions relative to the total feeding value of the crop. The question arises as to what effects some of the important production practices, such as the rate of applied nitrogen, number of plants per acre, and hybrid used, have on the development and/or nutritive value of the plant components.

In order to answer some of these questions an experiment was initiated in 1970 at the Southeast Louisiana Dairy and Pasture Experiment Station, Franklinton, La., to study the effects of varying nitrogen rates and plant populations on the yield and nutritive value of three selected corn hybrids and their components. The experiment was conducted three continuous years under field conditions.

REVIEW OF LITERATURE

Cummins (*3*)[2] reported maximum green and dry forage yields were produced with 150 pounds of applied nitrogen per acre with adequate phosphorus and potassium. Nitrogen fertilization increased ear percentage and decreased stem percentage but did not affect leaf percentage of corn. Digestible dry matter percentage of the whole corn plant was increased by the application of 50 pounds of nitrogen per acre over zero nitrogen. However, there was no increase in the digestibility when nitrogen rates were increased above 50 pounds per acre.

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[2] Italic numbers in parentheses refer to list of References, page 24.

Boswell et al. (*2*) found that ear weight decreased with increasing population and increased with irrigation. Factors which acted to reduce ear weight usually also acted to increase ear count. Therefore, the effect of ear size on yield was usually more than offset as far as grain was concerned. The shelling percentage of corn was not affected by nitrogen supply or plant population. Within a given plant population, grain protein content increased as the amount of applied nitrogen increased. Grain protein decreased as yield increased. Little increase in grain yield was obtained by using 120 or 240 pounds of nitrogen per acre as compared with 60 pounds. The three populations—10,000, 15,000, and 20,000 plants per acre—did not vary greatly in their influence on yields.

Data reported by Kroth et al. (*7, 8*) indicated that, generally, grain yield of corn peaked with 150 pounds of applied nitrogen at plant densities ranging from 13,000 to 15,000 plants per acre. These findings were over two years at four locations.

Horrocks et al. (*6*) in their work on shelling percentage of corn reported that shelling percentage varied significantly with location and with years. Delayed planting date resulted in lowering the shelling percentage. Hybrids differed significantly in shelling percentage regardless of whether a single-cross, double-cross, or an inbred line was involved. Shelling percentage increased with increased levels of nitrogen through 240 pounds per acre, and with increased plant populations through 24,000 plants per acre.

EXPERIMENTAL PROCEDURE

The experimental design utilized in this study was a randomized complete block in a 3 x 4 x 3 factorial arrangement with three replications. Three rates of applied nitrogen (100, 200, and 300 pounds per acre), four population levels (15,000, 20,000, 25,000, and 30,000 plants per acre), and three hybrids (Pioneer brand 3009, Coker 71, and Funk G-4949) were used in all possible combinations.

The experiment was conducted on a Providence silt loam soil with a 3 to 5 percent slope. Prior cropping history of the experimental site included the growing of annual grasses for grazing in the winter seasons and the production of corn or sorghum for silage during the summer seasons. An analysis of soil from the site prior to initiation of the study showed the following:

Depth	P	K	Ca	Mg	pH	O.M.
Inches	- - - - - - - - - - - -	Parts per million	- - - - - - - - - - - -			%
0-4	108	75	575	47	5.5	2.02
4-8	59	55	540	51	5.3	1.52

A broadcast application of two tons of dolomitic limestone per acre was plowed in during March of 1970. Phosphorus (P_2O_5) and potassium (K_2O) were applied annually at the rate of 200 and 300 pounds per acre, respectively. Ammonium nitrate, triple superphosphate, and muriate of potash were the sources of N, P, and K. Zinc sulfate was applied uniformly at the rate of 10 pounds per acre in 1972 only.

The nitrogen, phosphorus, and potassium were applied broadcast and disced in each year prior to planting. Plantings were made on a flat bed on 36-inch centers. Three seed were hand dropped in the drill at intervals necessary to provide the four plant populations. The stands were thinned to one plant per hill during the seedling stage. Two pounds of Aatrex 80W (atrazine) per acre were applied pre-emerge for weed control. The crop was cultivated twice each season to establish some ridging to reduce sheet erosion. The hybrids were recommended full-season, four-way crosses. Planting dates were April 28, 1970, April 7, 1971, and April 12, 1972. Irrigations numbered three, five, and three for 1970, 1971, and 1972, respectively. Approximately one acre-inch of water was applied at each irrigation. The harvest dates were July 28, 1970, July 26, 1971, and July 24, 1972.

The center row of three-row plots was hand harvested to a stubble height of one foot when the grain reached the hard-dent stage of maturity to determine total forage yields. Ten stalks were taken from each replication of each treatment combination to determine (1) the percentages of plant components on both a green- and a dry-weight basis, (2) percent dry matter of the entire plant and the components, and (3) quality measurements of the plant components. Two stalks were likewise taken for quality determinations of the entire plant. All samples were dried in an electrically heated, forced air, thermostatically controlled drier in which the temperature did not exceed 131° F. Samples for quality determinations were ground in a Wiley mill with a 1-mm screen and stored in plastic bottles until analyzed.

Crude protein determinations were made following A.O.A.C. procedures (*1*). Cell wall constituents (CWC) and acid detergent fiber (ADF) were determined by the Van Soest procedure (*5*). The Van Soest procedure for *in vitro* digestible dry matter (DDM) assay was modified by supplying 0.05 percent glucose and 0.25 percent urea to the buffer solution in each fermentation tube. Analyses of variance, Duncan's Multiple Range Tests, coefficients of variation, and correlations were calculated for the variables under investigation according to Snedecor (*10*).

RESULTS AND DISCUSSION

I. Agronomic Measurements

A. Entire Corn Plant

Data involving yield and dry matter content on the entire corn plant basis, and shelling percentage are reported in Tables 1-5. The entire corn plant refers to all of the plant that was harvested. Shelling percentage was determined by dividing the total dry weight of the grain and cob into the dry weight of the grain. Data for two years combined, 1971 and 1972, are reported in Tables 1, 2, 3, and 5. Data for 1970 are reported in Table 4.

1. Nitrogen Effects on Yield

There was a significant increase in the yield of green and dry forage and in yield of the grain at the 200-pound rate of nitrogen over the 100-pound rate (Table 1). The increases in forage yields were 2,792 pounds on a green basis and 1,299 pounds on a dry basis per acre. Grain production was increased by 480 pounds per acre. Increasing the nitrogen rate from 200 to 300 pounds per acre did not further increase forage or grain yields as an average over all populations and hybrids. Dry matter content of the entire plant and the shelling percentage of the ear were not affected by nitrogen rates. Year x nitrogen interaction was not significant, indicating that yield response to nitrogen rates was similar between the 1971 and 1972 seasons.

Table 1.—Effect of rates of nitrogen as an average over 15,000, 20,000, 25,000, and 30,000 plants per acre and three corn hybrids on forage and grain yields for silage, 1971-72

	Forage yields (lbs/a)		Dry grain (lbs/a)
Nitrogen rate	Green	Dry	
100 lbs/a	39,873 a	13,328 a	4,628 a
200 lbs/a	42,665 b	14,627 b	5,108 b
300 lbs/a	42,642 b	14,447 b	5,031 b
Coef. of var.	10.5	14.3	19.4

Values followed by the same letters in columns are not significantly different at $P < .05$.

2. Plant Population Effects on Yield

Green and dry forage yields increased significantly as the plant population was increased from 15,000 to 20,000 plants per acre, as an average over nitrogen rates and hybrids (Table 2). The increases were 2,427 pounds of green forage and 1,175 pounds of dry forage per acre. There was no significant effect on either green or dry forage yield as a result of increasing the plant population beyond 20,000 plants per acre. A significant year x population interaction indicates that the green and dry forage yield responses to population were affected differently between the 1971 and 1972 seasons. This finding has been reported by other researchers (*4, 6, 7*).

Grain yield was significantly higher at the 20,000-plant population over the 15,000-plant population. However, grain yield differences between the 20,000-, 25,000-, and 30,000-plant populations were not significant.

Percent dry matter of the entire plant and shelling percentage were not significantly affected by plant population.

Table 2.—Effect of plant population as an average over 100, 200, and 300 pounds of nitrogen per acre and three corn hybrids on forage yields for silage, 1971-72

Population	Forage yields (lbs/a) Green	Dry
15,000/a	39,607 a	13,270 a
20,000/a	42,034 b	14,445 b
25,000/a	42,294 b	14,212 b
30,000/a	42,972 b	14,609 b
Coef. of var.	10.5	14.3

Values followed by the same letter in columns are not significantly different at $P < .05$.

3. Nitrogen × Population Interaction on Green Forage Yield

Nitrogen × population interaction was significant, indicating that green forage yield response to populations differed within nitrogen rates. Yields at all rates of nitrogen and all plant populations averaged over the three hybrids are shown in Table 3. At the 100-pound nitrogen rate, yield was significantly lower at the 15,000-plant population compared with the other plant populations. At the 200-pound nitrogen rate, the 25,000-plant population yield was significantly higher than yields of both the 15,000- and 30,000-plant populations. When the nitrogen rate was increased to 300 pounds per acre, yield of the 30,000-plant population was significantly higher than that of the other three populations.

Within the 15,000-plant population, yield was significantly higher at the 200-pound per acre nitrogen rate over the 100-pound rate. There was no difference in yields between the 200- and 300-pound nitrogen rates. There were no differences in yields between all three nitrogen rates at the 20,000-plant population. With 25,000 plants per acre, yield was

Table 3.—Effect of rate of nitrogen and plant population as an average over three corn hybrids on pounds green forage per acre for silage, 1971-72

	Pounds nitrogen per acre			
Population	100	200	300	Average
15,000/a	37,239 a^1	40,940 a^2	40,641 a^2	39,607 a
20,000/a	40,864 b^1	43,104 ab^1	42,136 a^1	42,034 b
25,000/a	40,783 b^1	44,878 b^2	41,220 a^1	42,294 b
30,000/a	40,608 b^1	41,737 a^1	46,572 b^2	42,972 b
Average	39,873^1	42,665^2	42,646^2	

Values followed by the same letter in *columns* are not significantly different at $P < .05$.
Values with same numeral superscript in *lines* are not significantly different at $P < .05$.

significantly higher at the 200-pound nitrogen rate over yields at the 100-pound and 300-pound rates. The yield of the 30,000-plant population was significantly higher at the 300-pound nitrogen rate over the 100- and 200-pound rates. These data indicate that, generally, as plant populations were increased from 15,000 to 30,000 plants per acre, a need existed for increased amounts of nitrogen to support increased green forage yields. As seen in the averages, yields peaked significantly at the 200-pound rate of nitrogen and at the 20,000-plant population.

4. Hybrid Effects on Yield and Dry Matter Content

Southern corn leaf blight (*Helminthosporium maydis,* race T) occurred in epidemic proportions in 1970. Data for the 1970 season are reported in Table 4 separately from the data of the 1971-72 seasons. The 1970 data were analyzed statistically and reported separately for two reasons: (1) The large differences in the response to treatments between the 1970 season and the 1971-72 seasons; (2) the elimination of susceptibility of corn to the causal organism beginning in 1971 by substituting Texas sterile cytoplasm for normal cytoplasm.

The yield of Coker 71 apparently was affected to a greater extent by the southern corn leaf blight in 1970 than were yields from Pioneer 3009 and Funk G-4949. This is substantiated by Coker 71 having a higher disease rating. The forage and grain yields of Pioneer 3009 and Funk G-4949 were not significantly different, but their yields were significantly higher than the yield of Coker 71. The detrimental effects of the blight on the leaves and husks apparently lowered grain yields. Both forage and grain yields were much lower in 1970 than in 1971-72 (Tables 4 and 5).

Percentage of dry matter among the three hybrids was not significantly different in 1970; however, the hybrids did differ in percentage of dry matter as an average of the two years 1971-72. The lack of a difference in 1970 probably was due in part to the more rapid loss of water

Table 4.—Forage yields, percent dry matter, grain yield, and disease rating of three corn hybrids for silage averaged over 100, 200, and 300 pounds of nitrogen per acre and 15,000, 20,000, 25,000, and 30,000 plants per acre, 1970

	Forage yields (lbs/a)		%		
Hybrid	Green	Dry	Dry matter	Grain (lbs/a)	Disease rating*
Pioneer 3009	30,665 b	10,443 b	34.1 a	3,400 b	7.4 a
Coker 71	21,333 a	7,390 a	34.6 a	2,016 a	9.6 b
Funk G-4949	30,672 b	10,328 b	33.7 a	3,061 b	7.7 a
Coef. of var.	13.8	16.5	10.9	27.0	11.8

**Helminthosporium maydis*, race T. 0—no disease symptoms; 5—leaves of upper half of the plant affected; 10—entire plant affected.

Values followed by the same letter in columns are not significantly different at $P < .05$.

from plant tissue resulting from necrosis associated with blight development. This abnormal reduction in moisture content evidently obscured the inherent differential in drying rate among the hybrids during this period of maturation. Also, wet, cloudy weather during the harvesting period in 1970 probably kept the necrotic tissue saturated with free moisture and lowered the dry matter content in all three hybrids.

Yields, dry matter contents, and shelling percentages are reported in Table 5. The adverse effects of southern corn leaf blight were not evident in 1971-72. There were no significant differences in the mean green forage yields of the hybrids tested. Funk G-4949, however, was significantly more productive in forage on a dry matter basis than was Pioneer 3009 or Coker 71. This was accounted for, in part, by significant differences in percentage of dry matter among the hybrids, although all hybrids were harvested at the same apparent stage of maturity. Funk G-4949 was higher in dry matter content by 5.4 percent than was Pioneer 3009. The dry matter contents of these hybrids were within the range considered desirable for good ensilage processes.

Funk G-4949 produced 2,221 more pounds of dry forage per acre than did Pioneer 3009, and 1,720 pounds more than did Coker 71. The dry forage yields of Pioneer 3009 and Coker 71 were not statistically different. Funk G-4949 produced 962 more pounds of grain than Pioneer 3009 and 711 pounds more than Coker 71. Funk G-4949 ranked highest and Pioneer 3009 ranked lowest in grain yield and shelling percentage. Coker 71 was intermediate in respect to these two measurements. All three hybrids responded similarly to nitrogen rates and plant populations in regard to yields of forage and grain and to the dry matter content of the entire plant.

Table 5.—Forage yields, percentage dry matter, grain yields, and shelling percentages of three corn hybrids for silage as an average over 100, 200, and 300 pounds of nitrogen per acre and 15,000, 20,000, 25,000, and 30,000 plants per acre, 1971-72

Hybrid	Forage yields (lbs/a) Green	Forage yields (lbs/a) Dry	% Dry matter	Dry grain (lbs/a)	Shelling percentage
Pioneer 3009	42,440 a	13,293 a	31.5 a	4,518 a	74.8 a
Coker 71	41,062 a	13,694 a	33.6 b	4,769 a	78.1 b
Funk G-4949	41,678 a	15,414 b	36.9 c	5,480 b	80.6 c
Coef. of var.	10.5	14.3	11.1	19.4	10.4

Values followed by the same letter in columns are not significantly different at $P<.05$.

B. Plant Components

Tables 6 and 7 show the percentages of plant components on a green and a dry basis in the corn for silage, and the dry matter content of each component.

1. Nitrogen Effects on Plant Components

Nitrogen rates, as an average over populations and hybrids, had no effect on percentage of leaves on a green or dry basis (Table 6) or on the dry matter content of leaves (Table 7). The percentage of green stems was significantly higher at the 200-pound rate of nitrogen over the 100-pound rate. The numerical difference between the highest and lowest percentages of green stems due to nitrogen effects was only 0.8 percent. Nitrogen rates did not alter percentage of stems on a dry basis or the dry matter content of the stems. The percentage of green husks was significantly higher at the 300-pound rate of nitrogen over the 100-pound rate. Percentage of dry husks was significantly higher at the 300-pound rate over the two lower rates. Nitrogen rates did not affect the percent dry matter of husks.

The percentage of ears on a green basis was not affected by changes in nitrogen rate, but the dry matter content of ears was significantly higher at the 200-pound rate of nitrogen over the 100-pound rate. The percentages of cobs and grain on a dry basis was not affected by nitrogen rates. There was a significant year effect on all components except husks on a dry basis and ears on a green basis. These data indicate that although increased nitrogen rates from 100 to 200 pounds per acre increased forage and grain yields, generally the components and their respective dry matter contents remained in the same relative proportions.

2. Population Effects on Plant Components

Plant population had a small but significant effect on percentage of green leaves of the entire plant. The leaf component at the 25,000-plant population was 0.9 percent higher than that of the 15,000-plant population. However, there was a significant increase in percentage of dry leaves and in the dry matter content of leaves with each plant population increase over the 15,000-plant population. The magnitude of the differences in percentage of dry leaves and in the dry matter content of the leaves increased as plant population increased.

The increase in percentage of leaves on a dry basis as plant population increased was probably a result of the effect of plant population on percent dry matter. The higher dry matter content of leaves at the higher plant populations indicates the increased interplant competition for water, plant nutrients, and sunlight. These factors, coupled with possibly a higher humidity at the leaf surfaces, may have decreased the turgidity of plant cells in the leaves, resulting in a relatively higher dry matter content of the leaves.

Percentage of stems on a green basis increased significantly at the 20,000- over the 15,000-plant population, and at the 30,000- over the 20,000-plant population. On a dry basis, stems were significantly higher at the 25,000- and 30,000-plant populations over the 15,000- and 20,000-plant populations. Dry matter content in stems generally increased with increased plant population. Stems of corn plants have the capacity to adjust in stem diameter depending on population density. Thus, the higher the plant population per unit area, the smaller the diameter of the stems. Consequently, the percentage of stems changed little relative to plant population.

The percentage of husks on a green and a dry basis decreased significantly as plant population increased from 15,000 through 25,000 plants per acre (Table 6). Dry matter content of husks increased significantly only at the 30,000-plant population over the 15,000- and 25,000-plant populations (Table 7). Ear size decreases as plant population per unit area increases, so apparently percentage of husks varied proportionately relative to ear size in plant populations from 15,000 through 25,000 plants per acre.

There was no significant mean effect of population density on the percentage of ears on a green basis, or on dry matter content of the ears.

Although measurements of ear size were not taken in this study, probably ear size decreased proportionately relative to ear numbers and plant population density per unit area. Apparently, rate of maturity of the ears and dry matter accumulation in the grain were not altered by changes in plant population. As the population increased from 20,000 plants per acre to 30,000 plants per acre, the percentage of dry cobs decreased significantly. A 0.8 percent total decrease in cobs occurred between the lowest and the highest plant population.

The grain content was numerically highest at the 20,000-plant population. This component was significantly higher at the 15,000- and 20,000-plant populations over that in the 30,000-plant population.

3. Hybrid Effects on Plant Components

There were no significant differences in percentage of leaves on either a green or dry basis due to hybrid. However, the percent dry matter in the leaves of Funk G-4949 was significantly higher by 2.0 percent than was that in the leaves of Pioneer 3009.

The percentages of green and dry stems were significantly lower in Pioneer 3009 than in either Coker 71 or Funk G-4949. The percentage difference in stems between these hybrids was greater on a dry basis than on a green basis. There were no differences in percentage of stems on the green or dry basis between Coker 71 and Funk G-4949. The widest difference in dry matter content of stems occurred between Funk G-4949 and Pioneer 3009, the latter being lower by 3.5 percent. Coker 71 was intermediate in percent dry matter of the stems.

Significant differences occurred in percentage of husks on both the green and the dry basis, and in percent dry matter among hybrids. The percentage of husks was lowest in plants from Funk G-4949 on the green basis and from Funk G-4949 and Coker 71 on the dry basis. Husks of Coker 71 had a lower dry matter content than those of Funk G-4949 and Pioneer 3009.

Pioneer 3009 was highest in percentage of ears, followed by Funk G-4949 and Coker 71. However, in dry matter content in ears, the rank-

Table 6.—Mean effects of nitrogen rates, plant populations, and hybrids on percentages of plant components in corn for silage, 1971-72

	Percentage, green basis				Percentage, dry basis				
Main factors	Leaves	Stems	Husks	Ears	Leaves	Stems	Husks	Cobs	Grain
Nitrogen									
100 lbs/a	30.2 a	30.6 a	10.7 a	28.5 a	24.0 a	22.4 a	9.0 a	10.1 a	34.4 a
200 lbs/a	29.8 a	31.4 b	10.9 ab	27.9 a	24.4 a	22.2 a	9.2 a	9.9 a	34.6 a
300 lbs/a	29.6 a	31.1 ab	11.4 b	27.9 a	23.8 a	22.3 a	9.7 b	9.7 a	34.6 a
Population									
15,000/a	29.3 a	29.5 a	13.5 c	27.7 a	22.4 a	21.2 a	11.3 c	10.2 b	35.0 b
20,000/a	29.9 ab	30.7 b	10.8 b	28.5 a	23.4 b	21.9 a	9.2 b	10.1 b	35.5 b
25,000/a	30.2 b	31.5 bc	10.1 a	28.1 a	24.6 c	23.0 b	8.4 a	9.8 ab	34.3 ab
30,000/a	30.0 ab	32.4 c	9.6 a	28.0 a	25.9 d	23.1 b	8.3 a	9.4 a	33.4 a
Hybrid									
Pioneer 3009	29.8 a	29.9 a	11.2 b	29.1 c	24.1 a	20.4 a	10.2 b	11.5 c	33.9 a
Coker 71	29.7 a	31.7 b	11.5 b	27.2 a	23.8 a	23.2 b	8.8 a	9.7 b	34.6 a b
Funk G-4949	30.1 a	31.5 b	10.3 a	28.0 b	24.3 a	23.3 b	8.9 a	8.5 a	35.2 b
Coef. of var.	7.3	7.6	15.4	8.6	10.0	10.0	16.9	14.1	10.4

Values followed by the same letter in columns are not significantly different at $P < .05$.

ing of the hybrids from highest to lowest in numerical values was Funk G-4949, Coker 71, and Pioneer 3009. Significant differences in dry cob percentages were noted among hybrids. Cob content in plants from Pioneer 3009 was 3.0 percent greater than that from Funk G-4949.

The percentage of grain in Funk G-4949 was significantly higher than that in Pioneer 3009. A negative relationship between cob content and grain content among the hybrids was detected in the data.

These results indicate that the most valuable component of corn for silage—grain—remained at about one-third of the entire plant regardless of the level of applied nitrogen, population density, or hybrid utilized. It should be mentioned, however, that the mean percentage of grain in the crop was reduced by significant amounts as plant population increased.

Two plant components, leaves and stems, contributed approximately equal amounts to the crop yield, about 30.0 percent and 23.0 percent on a green and a dry weight basis, respectively. Population density and hybrid tended to influence the mean percentage of stems to a greater extent than they did the mean percentage of leaves. Husks and cobs each made up about 10.0 percent of the crop yield.

The mean dry matter content of the ear component was slightly more than 50.0 percent. Hybrid was the only treatment variable that appreciably influenced dry matter content of ears. A significant interaction between years and hybrid suggests a differential response of hybrid in the 1971-72 seasons of this experiment with regard to percent dry matter in the ears.

Mean dry matter percentages of the leaves and husks were slightly higher than the mean dry matter percentage of the stems. This illustrates

Table 7.—Mean effects of nitrogen rates, plant populations, and hybrids on dry matter content of plant components in corn for silage, 1971-72

	Percent dry matter			
Main factors	Leaves	Stems	Husks	Ears
Nitrogen				
100 lbs/a	26.4 a	23.9 a	28.1 a	50.9 a
200 lbs/a	27.2 a	23.2 a	27.9 a	51.9 b
300 lbs/a	26.7 a	23.2 a	28.0 a	51.3 ab
Population				
15,000/a	24.4 a	22.7 a	26.9 a	51.6 a
20,000/a	25.8 b	23.1 ab	27.9 ab	51.9 a
25,000/a	27.3 c	23.9 bc	27.6 a	51.2 a
30,000/a	29.6 d	24.0 c	29.5 b	50.9 a
Hybrid				
Pioneer 3009	26.0 a	21.7 a	29.3 b	49.4 a
Coker 71	26.4 a	23.4 b	25.0 a	51.8 b
Funk G-4949	28.0 b	25.2 c	29.6 b	52.9 c
Coef. of var.	14.4	9.9	16.2	6.2

Values followed by the same letter in columns are not significantly different at $P < .05$.

the fact that the stems had a higher moisture content at the time of harvest than did the leaves or husks. Both population density and hybrid affected the mean dry matter percentages of leaves, husks, and stems. However, the level of applied nitrogen did not influence dry matter content of these three components. The failure of applied nitrogen levels to affect the dry matter content of leaves, stems, and husks was unexpected.

II. Quality Measurements

A. Entire Plant and Plant Components

Plant cells may be broken down into two basic fractions, that is, cell content and cell wall constituents (CWC). Cell content is considered 98 percent digestible and is acted on by the animal enzymatic system. The CWC include the fibrous portion that is acted on by the enzymatic systems and rumen microflora. Acid detergent fiber (ADF) is fractionated from the CWC. Cellulose and lignin values, composing the total fiber, more closely approximate the ADF values than do crude fiber values. Thus, researchers strive to find management practices that increase the digestibility of the fiber fraction, and/or increase the cell content.

An artificial-rumen laboratory procedure was used to provide a *relative* measure of the *in vitro* digestible dry matter (DDM) of forage.

Crude protein, another quality component studied, includes true protein and a vast array of nitrogenous compounds in the plant. Ruminant animals can, through the enzymatic processes of the rumen microflora converting the nitrogenous compounds to protein, utilize true protein in addition to the converted protein.

Mean percentages of CWC, ADF, DDM, and crude protein in the entire plant as well as in the plant components are presented in Tables 8 and 9 for rates of applied nitrogen, plant populations, and hybrids, over 1971-72. Mean percentages of DDM in the entire plant and crude protein in the entire plant and in the grain component for hybrids over nitrogen rates and populations for 1970 are shown in Table 10.

1. Nitrogen Effects on Quality

Nitrogen levels, as an average over plant populations and hybrids, had no significant effect on CWC in the entire plant, stems, husks, and cobs (Table 8). This indicates, also, that changes in nitrogen rates did not alter the percentage of the highly digestible cell content. A significant decrease in CWC of leaves was noted at the 200-pound nitrogen rate as compared with the 100-pound rate. However, the CWC of leaves at the 300-pound rate of nitrogen was not significantly different from that at the 100- and 200-pound rates (Table 8).

There was a significant decrease in the percentage of ADF in the entire plant at the 200-pound rate of nitrogen over the 100-pound rate. A significant decrease was noted in the percentage of ADF in leaves at the 300-pound rate over the 100-pound rate of nitrogen. However, the 200-pound rate of nitrogen resulted in a significant increase in the ADF of husks over both the 100- and 300-pound rates. Changes in nitrogen rates did not affect the ADF in stems and cobs.

The *in vitro* digestible dry matter (DDM) percentage of the entire plant and stems was significantly increased at the 200-pound rate of nitrogen over the 100-pound rate (Table 9). The DDM in leaves and in husks was unaffected by changes in nitrogen rate. The cob DDM, however, was significantly lower at the 200-pound rate compared with the other rates tested.

Crude protein content in the entire plant, and in all plant components except the cob, was significantly affected by rate of applied nitrogen (Table 9). There was a linear increase in protein content of the entire plant, leaves, stems, and grain as nitrogen rates increased. The largest increase in protein percentage in the leaves due to nitrogen rates occurred between the 100- and 300-pound increments. Within each nitrogen rate, the percent crude protein in the leaves was numerically higher than that in the grain. Protein content in the husks was significantly lower at the 100-pound rate of nitrogen than at the two higher rates, with no difference between the 200- and 300-pound rates.

2. Population Effects on Quality

Population, as an average over levels of applied nitrogen and hybrids, had a significant effect on percent CWC in the entire plant and in the leaves, stems, husks, and cobs. The significant increase in CWC in the entire plant occurred at the 30,000-plant population over the 15,000-plant population. Since grain was included in the entire plant, and since grain is relatively high in cell content, the effect of plant population on grain content may account for the resultant CWC percentages. It was pointed out earlier that grain content was significantly decreased at the higher plant population levels.

The CWC percentage in leaves was significantly lower at the 15,000-plant population than at the other three populations, with no differences detected between the latter. The CWC content in stems increased significantly at the 25,000- over the 20,000-plant population. Although CWC in husks increased with each increase in plant population, a significant difference only occurred between the 15,000-plant population and the 25,000- and 30,000-plant populations. The increase in CWC in the cobs was consistent with each increase in plant population except at the 30,000-plant population. Although CWC in cobs at the 30,000-plant population was not significantly different from that at the 15,000-plant population level, it was numerically lower.

Population had a significant effect on ADF in the entire plant and the plant components (Table 8). The ADF in the entire plants and in the leaves generally increased as population increased. However, plant population had an inconsistent effect on the ADF content in stems, husks, and cobs.

Table 8.—Mean effects of nitrogen rates, plant populations, and hybrids on cell wall constituents (CWC) and acid detergent fiber (ADF) in the entire plant and in the plant components of corn for silage, 1971-72

	Percent cell wall constituents (CWC)					Percent acid detergent fiber (ADF)				
Main factors	Entire plant	Leaves	Stems	Husks	Cobs	Entire plant	Leaves	Stems	Husks	Cobs
Nitrogen										
100 lbs/a	57.8 a	59.1 b	68.7 a	66.6 a	78.5 a	29.4 b	35.3 b	45.9 a	32.6 a	45.2 a
200 lbs/a	58.4 a	58.4 a	67.5 a	67.2 a	78.9 a	28.0 a	34.9 ab	46.9 a	33.4 b	44.2 a
300 lbs/a	58.1 a	58.8 ab	67.6 a	66.2 a	77.5 a	28.8 ab	34.4 a	46.3 a	32.2 a	44.8 a
Population										
15,000/a	57.0 a	57.6 a	67.1 a	65.4 a	76.8 a	27.3 a	34.0 a	45.9 ab	32.2 a	45.2 b
20,000/a	57.8 ab	58.9 b	66.2 a	66.2 ab	79.6 b	28.2 a	34.5 a	45.2 a	33.2 b	44.5 ab
25,000/a	57.9 ab	59.3 b	69.0 b	67.4 b	81.0 b	29.4 b	35.6 b	47.3 b	32.8 a b	45.9 b
30,000/a	59.8 b	59.2 b	69.4 b	67.6 b	75.8 a	30.2 b	35.4 b	47.1 b	32.7 a b	43.3 a
Hybrid										
Pioneer 3009	58.4 a	59.7 b	68.0 b	68.8 c	79.5 a	29.1 a	35.1 b	46.1 a	34.0 b	45.8 b
Coker 71	58.0 a	58.1 a	70.2 c	64.8 a	77.7 a	29.0 a	35.1 b	47.5 b	31.8 a	44.6 ab
Funk G-4949	58.0 a	58.5 a	65.6 a	66.3 b	77.8 a	28.2 a	34.4 a	45.3 a	32.4 a	43.8 a
Coef. of var.	9.4	3.9	6.4	6.0	8.7	10.1	4.8	7.5	7.3	8.0

Values followed by the same letter in columns are not significantly different at $P < .05$.

Table 9.—Mean effects of nitrogen rates, plant populations, and hybrids on *in vitro* digestible dry matter (DDM) and crude protein in the entire plant and in the plant components of corn for silage, 1971-72

	Percent digestible dry matter (DDM)					Percent crude protein					
Main factors	Entire plant	Leaves	Stems	Husks	Cobs	Entire plant	Leaves	Stems	Husks	Cobs	Grain[1]
Nitrogen											
100 lbs/a	77.1 a	75.9 a	55.7 a	72.1 a	52.7 b	7.4 a	10.5 a	3.4 a	4.2 a	2.9 a	10.2 a
200 lbs/a	78.2 b	76.1 a	57.1 b	70.2 a	50.3 a	7.8 b	11.2 b	4.1 b	4.4 b	3.0 a	10.8 b
300 lbs/a	77.5 ab	75.8 a	57.1 b	70.6 a	53.1 b	8.1 c	11.3 b	4.5 c	4.4 b	3.0 a	11.1 c
Population											
15,000/a	77.9 b	76.8 b	58.0 b	70.2 ab	50.8 a	7.9 b	11.4 b	3.9 a	4.6 b	2.9 a	10.7 ab
20,000/a	78.2 b	76.3 b	57.3 b	68.7 a	52.6 a	7.8 ab	11.0 ab	4.2 a	4.2 a	3.0 a	10.5 a
25,000/a	77.7 ab	75.5 a	55.6 a	71.6 bc	52.4 a	7.8 ab	10.9 ab	4.0 a	4.2 a	3.0 a	10.9 b
30,000/a	76.6 a	75.0 a	55.6 a	73.5 c	52.3 a	7.6 a	10.6 a	3.9 a	4.3 a	3.0 a	10.5 a
Hybrid											
Pioneer 3009	78.1 b	76.4 b	57.2 b	71.8 a	53.4 b	7.5 a	11.4 b	4.1 b	4.3 b	3.0 a	10.1 a
Coker 71	76.6 a	75.2 a	55.8 a	71.0 a	50.4 a	8.1 b	10.8 a	4.1 b	4.7 c	3.0 a	11.4 c
Funk G-4949	78.1 b	76.2 b	56.9 ab	70.2 a	52.3 b	7.7 a	10.7 a	3.8 a	4.0 a	2.9 a	10.5 b
Coef. of var.	4.1	2.6	6.7	8.1	9.8	8.0	10.3	19.5	13.0	15.0	6.0

Values followed by the same letter in columns are not significantly different at $P < .05$.

[1] 1972 only.

The *in vitro* DDM decreased in the entire plant, leaves, and stems as plant population increased, whereas the DDM of husks increased. Changes in plant population did not significantly alter the DDM in cobs.

Increasing the plant population had a significant effect of decreasing the crude protein level in the entire plant, the leaves, husks, and grain but not in the stems and cobs. The differences in the crude protein content of these measurements, where significant, were relatively small and not considered to be of practical importance.

3. Hybrid Effects on Quality

Hybrids, as an average over nitrogen rates and population densities, differed significantly in the percentages of CWC in the leaves, stems, and husks but not in the entire plant. Leaves of Pioneer 3009 were significantly higher in CWC than leaves of both Coker 71 and Funk G-4949. The percentage of CWC in the stems and in the husks was significantly different among all three hybrids, although the rankings of the values for the two components were not the same as for CWC. Comparatively, the percentage of CWC was lowest in stems and intermediate in husks for Funk G-4949, whereas CWC in stems and husks of Coker 71 ranked highest and lowest, respectively. Although there were no differences among the hybrids in CWC in the entire plant, these data suggest that real genetic differences in CWC exist in the leaves, stems, and husks.

There were significant differences among the hybrids in the percentages of ADF in leaves, stems, husks, and cobs but no difference in the ADF percentage in the entire plant. Although the differences in the numerical values of ADF measurements among hybrids were relatively small and somewhat inconsistent, overall, ADF was lowest in Funk G-4949, intermediate in Coker 71, and highest in Pioneer 3009.

The *in vitro* digestible dry matter (DDM) of the entire plant and of leaves, stems, and cobs was significantly higher in Pioneer 3009 and in Funk G-4949 over that in Coker 71. The DDM values of stems and cobs were lower than those in leaves and husks by approximately 20.0 percent, respectively.

Percentages of crude protein in the entire plant, husks, and grain were significantly higher in Coker 71 than in Pioneer 3009 and Funk G-4949. Crude protein contents were found in nearly equal amounts in both the leaf and grain components of all three hybrids. Stems and husks, averaged over all hybrids, contained about 4.0 percent crude protein, whereas approximately 3.0 percent was detected in cobs. The crude protein level in the entire plant, a function of the protein percentage in all plant components, would, of necessity, be intermediate between the highest and lowest percentages in the components. Results of this study show that percentage of protein in the entire plant was apparently more closely related to protein content in the grain that it was to protein levels in any of the other components.

As an average over all nitrogen levels, plant populations, and hybrids, the CWC percentage in the various components was highest in cobs, intermediate in stems and husks, and lowest in leaves. However, the ADF in husks ranked more nearly with that in leaves, and both of these components were lower in ADF than were stems and cobs. The overall mean values of DDM in the components indicate that a morphological and chemical similarity exists between leaves and husks and between stems and cobs. The fact that CWC content in husks ranked more nearly with that in stems, but ADF content in husks was considerably lower than that in stems, indicates perhaps a higher content of hemicellulose in the husks. The ADF content in stems and cobs was approximately 45 percent, whereas that in leaves and husks was about 34 percent, and the entire plant was 29 percent. The grain component, which contains about 5 percent fiber, diluted the ADF of the entire plant below that of leaves, stems, husks, and cobs.

Determinations were not made on DDM of the grain component. However, the DDM values obtained on the entire plant basis did involve grain. The high level of digestibility of grain was reflected in the DDM percentages of the entire plant of all the hybrids. The DDM values of the entire plant exceeded the DDM percentages of each of the four other components—leaves, stems, husks, and cobs. This was due to the favorable contribution of the grain segment to DDM in the entire plant.

The effect of southern corn leaf blight in 1970 on DDM values is evident in Table 10. The DDM values on the entire plant basis for the hybrids averaged over all nitrogen rates and population densities were lower by about 6.0 percent in 1970 than in the 1971-72 seasons. However, the crude protein content in the entire plant and in the grain component was slightly higher in the diseased year than in the seasons when the blight was not prevalent.

Table 10.—*In vitro* digestible dry matter (DDM) and crude protein in the entire plant and in the grain component of three corn hybrids for silage as an average over 100, 200, and 300 pounds of nitrogen per acre and 15,000, 20,000, 25,000, and 30,000 plants per acre, 1970

Hybrid	Percent DDM, entire plant	Percent crude protein	
		Entire plant	Grain
Pioneer 3009	72.7 b	8.3 a	10.6 a
Coker 71	71.3 a	9.8 b	12.0 c
Funk G-4949	71.5 ab	8.3 a	11.0 b

Values followed by the same letter in columns are not significantly different at $P < .05$.

III. Correlation Coefficients

Correlation coefficients involving certain variables measured in this experiment are shown in Tables 11-14.

Green forage yield per acre was correlated in a positive direction with dry forage yield per acre (Table 11). This reflects the high relationship between the treatments that enhanced increased yield on a green and dry basis. That is, at the stage of maturity the corn was harvested, the treatments that produced highest green forage yield produced highest dry forage yield. Generally, as pounds of green forage increased, the percent dry matter of forage decreased. This relationship was small, as evidenced by the low but significant correlation value. As the green forage yield increased, the percent dry matter of leaves, stems, and husks decreased. These data indicate that physiologic maturity in the plants had not been obtained.

The high positive relationships between pounds of dry forage per acre and percent dry matter of the entire plant and of the leaves, stems, husks, and ears are indicative of continued growth of the plant components at the hard-dough stage of maturity. Dry matter content of the ears increased significantly as the dry matter content of the entire plant increased. The dry matter content of stems and husks increased significantly as that in the leaves increased, but there was no relationship between the percent dry matter in leaves and ears. The dry matter content of stems was significantly correlated in a positive manner with that in husks and ears.

As the percentage of leaves on a dry basis decreased, pounds of grain per acre increased, implying that the treatments which decreased the leaf percentage increased grain yield per acre (Table 12). This indicates that the leaves of plants in treatments that decreased the dry leaf percentage were more efficient in the processes of grain production than were those in treatments that enhanced dry leaf percentage. The relationship of dry stem percentage to grain percentage was similar to that of leaves to grain. The high negative relationship of dry cob percentage to shelling percentage was probably a result of the method by which shelling percentage was determined.

Only a few of the correlation coefficients reported in Table 13, although statistically significant, were large enough to be considered important. Percentage of ADF in the entire plant and in leaves and stems was a better indicator of DDM than was CWC. The CWC of husks and cobs best indicated the DDM of these components, although these relationships were low.

The data in Table 14 indicate that the crude protein content in the entire plant was more nearly related to the crude protein content in the grain than to that in any of the other plant components. The protein content in the grain component was related more nearly to the protein in stems and husks than to that in the leaves and cobs. This does not contradict the fact that crude protein content in the grain and leaves was approximately the same, and that in the stems, husks, and cobs was approximately the same. It indicates that when main factors, namely nitrogen level and hybrid, altered the crude protein in the grain component, the crude protein in stems and husks was altered more so than that in leaves and cobs.

Table 11.—Correlation coefficients among forage yields and percent dry matter in the entire corn plant and in four components of corn for silage, 1971-72

	Lbs/a dry forage	Percent dry matter				
		Entire	Leaves	Stems	Husks	Ears
Lbs/a green forage	.65**	-.19**	-.47**	-.35**	-.30**	.24**
Lbs/a dry forage		.61**	.31**	.43**	.15*	.31**
% Dry matter entire plant			-.17*	.05	-.13*	.43**
% Dry matter leaves				.50**	.55**	-.02
%Dry matter stems					.32**	.30**
% Dry matter husks						.01

*Significant at P < .05. **Significant at P < .01.

Table 12.—Correlation coefficients among forage and grain yields, percentages of plant components on a dry basis, and shelling percentage in corn for silage, 1971-72

	Lbs/a grain	Percentage of components on a dry basis						Shelling percentage
		Leaves	Stems	Husks	Ears	Grain	Cobs	
Lbs/a dry forage	.90**	-.17*	-.04	-.21**	.25**	.38**	-.24**	.37**
Lbs/a grain		-.45**	-.25**	-.20**	.60**	.74**	-.18**	.51**
% Dry leaves			.21**	-.26**	-.75**	-.69**	-.27**	-.13*
% Dry stems				-.44**	-.66**	-.49**	-.48**	.17*
% Dry husks					.03	-.11	.32**	-.31**
% Dry ears						.90**	.39**	.12
% Dry grain							-.03	.54**
% Dry cobs								-.81**

*Significant at P < .05. **Significant at P < .01.

Table 13.—Correlation coefficients between cell wall constituents (CWC), acid detergent fiber (ADF), and *in vitro* digestible dry matter (DDM) in the entire corn plant and in plant components of corn for silage, 1971-72

	Percent *in vitro* digestible dry matter (DDM)				
	Entire plant	Leaves	Stems	Husks	Cobs
% CWC entire plant	-.24**	-.07	-.07	-.05	.03
% CWC leaves	.02	-.18**	.12	.29**	-.15*
% CWC stems	-.14*	-.08	-.40**	.16*	-.09
%CWC husks	-.14*	-.09	-.17*	-.14*	.22**
% CWC cobs	.03	-.05	-.04	.01	-.03
% ADF entire plant	-.46**	-.20**	-.04	.15*	-.08
% ADF leaves	-.12	-.38**	-.03	.15*	-.06
% ADF stems	-.05	.08	-.39**	.13	-.08
% ADF husks	.09	.02	-.08	-.11	.23**
% ADF cobs	-.01	-.05	-.03	-.03	-.04
% DDM entire plant		.21**	.21**	.12	-.13
% DDM leaves			.11	.16*	-.16*
% DDM stems				.49**	-.31**
% DDM husks					-.53**

*Significant at $P < .05$. **Significant at $P < .01$.

Table 14.—Correlation coefficients between crude protein percentages in the entire corn plant and in plant components of corn for silage, 1971-72

	Percent protein				
	Leaves	Stems	Husks	Cobs	Grain[1]
% Protein entire plant	.17*	.33**	.30**	.07	.42**
% Protein leaves		.11	.01	-.26**	-.03
% Protein stems			.36**	.22**	.47**
% Protein husks				.26**	.49**
% Protein cobs					.20*

*Significant at $P < .05$. **Significant at $P < .01$.

[1] 1972 only.

SUMMARY

Significantly higher total forage and grain yields occurred at the 200-pound per acre rate of nitrogen as compared with the 100-pound rate. There was no increase in forage or grain yields at the 300-pound rate of nitrogen over the 200-pound rate. Nitrogen rates had little effect on percentage of components of the plants or on the quality measurements of the components. Crude protein content, however, did generally increase with increased rates of nitrogen.

Total forage yields were significantly higher at the 20,000-plant population than they were at the 15,000-plant population. There were no yield differences between the 20,000-, 25,000-, and 30,000-plant populations. Grain yield was significantly higher at the 20,000-plant population than it was at the 15,000-plant population. There was no grain yield difference between the 20,000-plant population and the higher populations. As plant population increased, percentages of leaves and stems increased, whereas percentages of husks, ears, cobs, and grain tended to decrease. Generally, the dry matter content of the plant components, with the exception of ears, increased with increased population. Cell wall constituents (CWC) and acid detergent fiber (ADF) in the entire plant and in most plant components increased as plant population increased. Dry matter digestibility of the entire plant and of plant component leaves and stems decreased slightly as population density increased, whereas the DDM of husks increased with increased population levels. Protein content of the entire plant and of most plant components was slightly lower at the denser stands.

Pioneer 3009 yielded highest on a green forage basis and lowest on a dry forage basis. Funk G-4949 yielded highest on a dry forage basis. This reversal in yield rankings on green and dry forage bases was accounted for primarily by the differences in dry matter content of the forage among hybrids at the time of harvest, although all hybrids were harvested at the same apparent stage of maturity. Funk G-4949 was significantly higher in grain yield and in shelling percentage than the two other hybrids. There were greater differences among hybrids in the percentage of plant components on a dry basis than on a green basis. Differences among hybrids in quality properties of the entire plant and the leaf component were generally small although some significant differences involving DDM and crude protein did exist. Also, the hybrids differed slightly in quality determinations of the stems, husks, and cobs.

Total dry forage, percent dry matter, and grain yield were affected more by hybrid than by population density and nitrogen level. Percentages of plant components were altered more by plant population and hybrid than by nitrogen rate.

Forage and grain yields and the DDM of the entire plant were lower in 1970 than in the 1971-72 seasons. The decreases noted in 1970 were due, apparently, to the effect of infestation by southern corn leaf blight.

As green forage yield increased, the percent dry matter of leaves, stems, and husks decreased. However, as dry forage yield increased, the percent dry matter of these components increased. The data indicate that with the hybrids tested, high grain yields necessitate high forage yields. Treatment combinations that resulted in lower percentage of dry leaves also produced more grain. Significant differences in DDM values were detected, and generally ADF was a better predictor of DDM than was CWC.

Treatment effects on changes in crude protein content in grain were more closely related to the crude protein changes in stems and husks than in leaves and cobs. However, crude protein in the leaves and the grain accounted for most of the crude protein in the entire plant.

These results suggest the need for developing corn hybrids characterized by high grain potential, leafy plants, dense husks, small stems, and small cobs. It appears that by selecting the corn hybrid with the highest grain yield, and by using the production practices that maximize grain yield, the silage producer should expect a satisfactory tonnage of high quality feed.

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Corn Forage as Affected by Plant Population, Nitrogen Rate and Hybrid on Olivier Soil

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Corn Forage as Affected by Plant Population, Nitrogen Rate and Hybrid on Olivier Soil

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INTRODUCTION

Several thousand acres are devoted to the production of corn (*Zea mays* L.) silage by dairymen and beef producers in Louisiana. Investigations into the cultural requirements for maximum economic yield of corn silage have been very limited in the state. It has been generally assumed that those corn hybrids which show area adaptation in regard to grain yield should be utilized for silage production and that the desirable population density for silage production should exceed that for grain production. In response to many inquiries on the production of corn silage a project was initiated to study the forage-yield response of three full-season corn hybrids of approximately equal grain yield potential, but with somewhat different growth habits, to varying population densities and to different levels of applied nitrogen under nonirrigated conditions on Olivier silt loam, a Mississippi Terrace soil.

REVIEW OF LITERATURE

The value of corn silage as an energy source in the diet of farm animals, especially dairy cattle, has long been recognized by researchers and farmers. More recently, the quality of silage from corn, in terms of the ratio of ear to vegetative plant components, has received increased attention (*1, 2, 3, 4, 6, 8*).[6] Differences among corn hybrids in silage-yield potential have been noted (*4, 5, 9*), and the effects of population density on corn silage yield have been reported (*1, 3, 4, 6, 9*). The relationship between nitrogen fertilization and yield of silage from corn hybrids has been investigated in different sections of the United States (*2, 3, 5*).

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[6] Italic numbers in parentheses refer to Literature Cited, page 23.

Doss et al. (*3*), in Alabama, reported a corn silage-yield response from an increase in population level up to 74,000 plants per hectare (30,000 plants per acre). In Virginia, according to Genter and Camper (*4*), significant increases in total dry matter production by corn hybrids accompanied increases in population density from the minimum of 34,600 plants per hectare (14,000 plants per acre) to a maximum population level of 64,200 plants per hectare (26,000 plants per acre). In a publication by Rutger and Crowder (*9*), based on research conducted in New York, it was stated that maximum yields of both grain and corn silage were obtained at a planting rate of 70,000 plants per hectare (28,300 plants per acre), and in another article (*10*) they reported a silage-yield response up to 88,000 plants per hectare (35,600 plants per acre).

At dense plantings of corn in Alabama, the total dry matter yield increased significantly as the rate of applied nitrogen increased from 168 kg per hectare (150 pounds per acre) to 336 kg per hectare (300 pounds per acre) (*3*). Cummins (*2*) reported increases in both green and dry forage yields from corn with increases in nitrogen levels up to 150 pounds per acre in Georgia. A significant increase in dry matter yield of corn forage was noted from the addition of 100 kg of nitrogen per hectare (90 pounds per acre) in Wisconsin, but no additional response occurred as the nitrogen rate was increased above that level (*5*).

The value, regarding quality, of a high proportion of ears to vegetative plant parts in corn silage is evident from data given by Morrison (*7*). He reported *in vivo* digestibility of dry ears, leaves, and stalks (including ear shanks and tassels) to be 85.0, 60.1, and 49.2 percent, respectively.

Increases in plant population did not affect the plant-part ratio in corn silage (*4, 6*). It was noted by Genter and Camper (*4*) that plants tended to become proportionally smaller as the population was increased, so that the plant-component composition of the forage remained practically the same at all four population densities included in the study. Bryant and Blaser (*1*) found a decrease in the proportion of husks in corn forage as the population increased. According to Doss (*3*), the ratio of ears to plant weight increased with increases in population density. He reported that, as an average over treatment variables, the stalks comprised 45 percent, the ears 36 percent, and the leaves 19 percent of the total dry plant weight of corn forage.

Cummins (*2*) stated that corn produced a higher proportion of ears and a lower proportion of stalks and increased in *in vitro* digestibility when fertilized with 50 pounds of nitrogen per acre as compared with the check treatment. There was no effect on percent leaves in the forage from the addition of nitrogen to the crop. A high correlation between dry matter content and ear content was reported by Nevens et al. (*8*).

EXPERIMENTAL PROCEDURE

Three commercial full-season corn hybrids, Coker 74, Funk G-4949, and Pioneer brand 3009, all adapted to the area for grain production, were grown at four population densities, approximately 15,000, 20,500, 25,000, and 29,000 plants per acre, in all possible combinations with three levels of applied nitrogen, 100, 200, and 300 pounds per acre, at Baton Rouge during the period 1969-1972. A randomized-block design in a split-split plot arrangement with three replications was employed to measure response to the treatment combinations. The test was planted on Olivier silt loam, a Mississippi Terrace soil of medium-low fertility status.

Plant populations, from the minimum to the maximum densities, were obtained by the use of single-plant hill spacings of 11.5, 8.5, 7.0, and 6.0 inches, respectively, in 36-inch rows. The plots were hand planted with an excess of seed; the plants were thinned to the desired stand in the post-seedling stage. An attempt was made to compensate for missing hills by leaving two plants in hills adjacent to the skip so that near perfect stands were attained.

Ammonium nitrate (33.5 percent N) was the nitrogen source utilized; the nitrogen, 200 pounds of P_2O_5, and 250 pounds of K_2O per acre were broadcast by hand annually and disced into the soil to a depth of approximately 4 inches. All fertilizer was applied prior to planting each year.

Planting dates ranged from March 26 in 1970 to April 22 in 1969, with the plots being planted on April 13 in 1971 and in 1972. Immediately after planting, a broadcast treatment of 2.5 pounds of Aatrex 80W plus 1 quart of Lasso per acre was applied. Mechanical cultivation was not practiced in the plots.

Each plot consisted of three rows, 15 feet in length. The center row of the plot was harvested for silage evaluation; grain yields were based on the two outside rows of the plot. In both cases, silage- and grain-yield evaluations, one plant on each end of the plot row was not harvested in order to eliminate border effects.

For silage-yield determinations, the plants were cut by hand approximately 6 inches above the ground when grain development had reached the hard-dough stage. Total green forage weight was obtained for each plot. The silage harvest dates varied among the four years from July 10 to July 30, depending on date of planting; the harvest date was nearly 100 days from the planting date in each of the four years. At the time of silage harvest, two samples of five plants each were collected from each plot. One, called the whole-plant sample, was used for dry matter determinations and the other, referred to as the separation sample, was separated into five plant components, leaves, stems, grain, cobs, and husks, in order to measure the contribution of each plant component to total forage yield. The whole-plant samples were weighed immediately after collection to obtain green weight, then dried in a forage dryer at 150° F until moisture loss from the sample ceased. The dried samples were again weighed and the green and dry weights were used to determine percent dry matter.

To determine the composition of forage by plant component, each of the five components from the separation sample was completely dried in the forage dryer and the dry weight of each was obtained. Percentages of the plant components in the dry forage were calculated from the dry weight of each component divided by the total dry weight of all components in that sample and multiplied by 100.

Forage yields are reported in tons per acre on both the green- and the dry-weight basis. The forage composition is given in terms of percentages of the five plant components.

Grain-yield measurements were based on husked ear corn harvested from the two outside rows of each plot. Moisture content of the grain at harvest was estimated by means of a Model 400 Steinlite moisture tester. Shelling percent (ratio of grain to cob) was determined from ear samples taken from the plots at harvest. Plot grain weights were obtained by multiplying the plot ear weight by the shelling percent. The plot grain weights were adjusted to 15.5 percent grain moisture by application of the standard procedure for moisture content adjustment. Grain yields are given in units of bushels per acre of 15.5 percent moisture grain.

Other properties studied included the number of days to ½-silk, measured from planting date to the date when one-half of the plants in a plot showed silk emergence, plant and ear heights, expressed in feet, and percent stand.

The variables were subjected to an analysis of variance using Duncan's Multiple Range Test and all possible correlation coefficients among the variables were computed.

RESULTS AND DISCUSSION

All data are presented and discussed in terms of four-year averages, 1969-1972.

Yield and Percent Dry Matter

The analysis of variance of percent stand showed no significant effect, indicating that differences in stand did not influence the results of this study.

There was a significant effect of population density on forage yield as revealed by the analysis of variance of that variable. In Table 1 are included the mean forage yields, both green and dry, of the four population levels averaged over rates of applied nitrogen and corn hybrids. The coefficients of variability were very reasonable at 6.99 percent for green yield and 14.24 percent for dry yield.

Table 1.—Mean yields of forage at four population densities averaged over levels of applied nitrogen and hybrids

Population, plants/acre, thousands	Yield, green forage, tons/acre	Yield, dry forage, tons/acre
15.0	15.82 b*	4.72 b
20.5	17.00 b	5.04 ab
25.0	18.68 a	5.42 a
29.0	18.71 a	5.45 a
C.V.	6.99%	14.24%

*DMRT (Duncan's Multiple Range Test). Means within same column followed by same letter not considered significantly different at 0.05 level of probability.

Green forage yields at 25,000 and 29,000 plants per acre were significantly greater than at plant densities of 15,000 and 20,500 plants per acre. Green yields at the two lower populations did not differ, nor did yields at the two higher planting rates differ significantly. The maximum green yield produced was 18.71 tons per acre.

For dry forage yield, no significant increase occurred above the 20,500-plant population, although the dry yields at 25,000 and 29,000 plants per acre were about 0.4 ton per acre more than at the 20,500-plant density. Dry matter yields ranged from 4.72 to 5.45 tons per acre at the minimum and maximum populations, respectively.

Nitrogen effects on forage yield were significant and the nitrogen × hybrid interaction was significant for dry forage yield; however, this interaction was not significant for green yield. Table 2 contains the green forage yields at the three levels of applied nitrogen averaged over population densities and hybrids. A yield response was evident from the application of 200 pounds of nitrogen per acre; green yields of forage at the two higher levels of added nitrogen did not differ significantly. There was a 2.6-ton-per-acre increase in green yield from the use of 200 pounds of nitrogen over that of the 100-pound level.

Table 2.—Mean yields of green forage at three levels of applied nitrogen averaged over population densities and hybrids

Applied nitrogen, pounds/acre	Yield, green forage, tons/acre
100	15.84 b*
200	18.44 a
300	18.38 a

*DMRT—Means followed by same letter not considered significantly different at 0.05 level of probability.

Dry matter yields of the three hybrids at three levels of applied nitrogen averaged over population densities are reported in Table 3. The hybrid Pioneer brand 3009 produced significantly less dry forage at the 100-pound level of applied nitrogen than it did at the two higher rates. This hybrid showed no significant dry yield difference between 200 and 300 pounds of added nitrogen. The dry forage yield of Funk G-4949 was significantly greater at the intermediate rate than at either of the two other nitrogen levels. There was no significant difference between the extremes in nitrogen application in the dry matter yield of Funk G-4949. Coker 74 responded to 200 pounds of applied nitrogen in dry forage yield and, although the yields at 200 and 300 pounds per acre did not differ, both exceeded the yield at the lowest nitrogen rate.

Table 3.—Mean forage yields of three corn hybrids at three levels of applied nitrogen averaged over population densities

Hybrid	Applied nitrogen, pounds/acre 100	200	300
	Yield, dry forage, tons/acre		
Pioneer brand 3009	B[1] 5.01 a[2]	A 5.46 a	A 5.57 a
Funk G-4949	B 4.86 a	A 5.61 a	B 5.09 b
Coker 74	B 4.45 b	A 5.31 a	A 5.09 b

[1] DMRT—Means within same *row* preceded by same *capital* letter not considered significantly different at 0.05 level of probability.

[2] DMRT—Means within same *column* followed by same *small* letter not considered significantly different at 0.05 level of probability.

A comparison of hybrid performances within levels of applied nitrogen shows that the dry matter yields of the three hybrids did not differ significantly at the intermediate level of nitrogen application. At the 100-pound rate, the yields of Pioneer brand 3009 and Funk G-4949 were not different, but both hybrids outyielded Coker 74 significantly. Pioneer brand 3009, at 300 pounds per acre of added nitrogen, produced significantly more dry matter than did the two other hybrids, whose yields were identical at that level of fertilization.

These data indicate that all three hybrids are suitable for silage production from the standpoint of dry matter yield, and that 200 pounds of applied nitrogen per acre should be used for maximum dry forage yield.

Percent dry matter of the forage was influenced significantly by population density and level of applied nitrogen; too, there was a significant interaction between populations and nitrogen levels for percent dry matter expression. The effects of population density and nitrogen rate on percent dry matter content are given in Table 4. The coefficient of variability for percent dry matter was 5.70 percent, indicating very reliable results.

Table 4.—Mean percent dry matter in forage at four population densities and three levels of applied nitrogen averaged for hybrids

Applied nitrogen, pounds/acre	Population, thousands plants/acre 15.0	20.5	25.0	29.0
	Dry matter, %			
100	B[1] 29.53 a[2]	A 30.69 a	B 29.18 a	AB 30.55 a
200	A 29.44 a	AB 29.39 b	B 28.36 b	AB 28.78 b
300	AB 28.62 b	A 29.00 b	AB 28.46 b	B 27.79 c

[1] DMRT—Means within same *row* preceded by same *capital* letter not considered significantly different at 0.05 level of probability.

[2] DMRT—Means within same *column* followed by same *small* letter not considered significantly different at 0.05 level of probability.

Under the nitrogen regime of 100 pounds per acre, the percent dry matter did not differ significantly among populations of 15,000, 25,000, and 29,000 plants per acre, but percent dry matter was significantly higher with 20,500 plants than with 15,000 and 25,000 plants. At 200 pounds of nitrogen there were no differences in percent dry matter among the two lowest and the highest population densities; the minimum plant population yielded a higher percent dry matter than did the 25,000 population at 200 pounds of nitrogen. Percent dry matter was significantly greater at 20,500 plants than at 29,000 plants with 300 pounds of applied nitrogen.

Within-population comparisons of nitrogen levels reveal a significantly lower dry matter percent at 300 pounds than at 100 or 200 pounds of nitrogen at the minimum population density. At the two intermediate populations, there was no significant difference in percent dry matter between 200 and 300 pounds of nitrogen; both of these nitrogen levels produced forage with lower dry matter percentages than that of the 100-pound level at 20,500 and 25,000 plants per acre. A negative, linear relationship was evidenced between nitrogen level and percent dry matter at the maximum population density. With each additional increment of nitrogen, at that population, the percent dry matter decreased significantly. At all population levels percent dry matter was greatest at the minimum rate of applied nitrogen, which was expected. The extra nitrogen tended to maintain the plant tissue at a higher water content, and this tendency was most pronounced at the highest plant density, where plant competition accentuated the differences in available nitrogen.

Hybrid means for percent dry matter and grain yield are reported in Table 5. The three hybrids differed in both properties, with Pioneer brand 3009 producing forage with the highest dry matter percent and the largest grain yield. Coker 74 yielded the lowest percent dry matter and grain yield.

Table 5.—Mean percent dry matter in forage and grain yield of three corn hybrids averaged over population densities and levels of applied nitrogen

Hybrid	Dry matter, %	Yield of grain, bushels/acre
Pioneer brand 3009	30.43 a*	97 a
Funk G-4949	28.94 b	89 b
Coker 74	28.07 c	83 c
C.V.	5.70%	11.73%

*DMRT—Means within same column followed by same letter not considered significantly different at 0.05 level of probability.

Grain yield showed a significant interaction between populations and nitrogen levels. Grain yields in all combinations of population densities and nitrogen levels averaged over hybrids are presented in Table 6. At the three lower plant densities, grain yield responded to the 200-pound nitrogen application, but there was no additional response above that level of nitrogen. A significant increase in yield accompanied each increment of applied nitrogen at the maximum population, and the highest numerical yield occurred with the treatment combination of 300 pounds of nitrogen and 29,000 plants per acre. However, this 106-bushel yield probably did not differ significantly from the 101 bushels produced from 200 pounds of applied nitrogen at 25,000 plants per acre.

Table 6.—Mean grain yields at four population densities and three levels of applied nitrogen averaged for hybrids

Population, plants/acre, thousands	Applied nitrogen, pounds/acre		
	100	200	300
	- - - - - - - - Grain yield, bushels/acre - - - - - - - -		
15.0	B[1] 77 b[2]	A 90 b	A 88 c
20.5	B 75 b	A 91 b	A 92 bc
25.0	B 85 a	A 101 a	A 99 ab
29.0	C 76 b	B 96 ab	A 106 a

[1] DMRT—Means within same *row* preceded by same *capital* letter not considered significantly different at 0.05 level of probability.

[2] DMRT—Means within same *column* followed by same *small* letter not considered significantly different at 0.05 level of probability.

The 25,000-plant density produced significantly more grain than did the three other planting rates at the 100-pound level of nitrogen. At the 200-pound rate, the yield from 25,000 plants exceeded those of the 15,000- and 20,500-plant populations. The two lower populations did not differ in grain yield at 300 pounds of nitrogen per acre, nor did the two higher population densities differ in this respect at the maximum nitrogen rate.

Flowering Date, Plant Height, and Ear Height

The influence of cultural practices on the elapsed time between planting and silk emergence in the corn field is of interest to the silage producer, because in situations where large acreages are involved, harvest over an extended period is necessary, and ensiling the crop at the proper stage of kernel development becomes a serious problem. Any practice which would hasten or delay maturity might be applicable to part of the acreage as a means of improving the timeliness of harvest.

Significant effects on silking date were exhibited by all three treatment variables, population density, level of applied nitrogen, and hybrid. In addition, a significant interaction was shown between populations and hybrids. Table 7 contains mean values of the number of days to ½-silk at the three nitrogen rates averaged over population densities and hybrids. The coefficient of variation for this variable was extremely low at 1.30 percent.

Table 7.—Mean number of days from planting to ½-silk and mean plant heights at three levels of applied nitrogen averaged over population densities and hybrids

Applied nitrogen, pounds/acre	Days to ½-silk, number	Plant height, feet
100	71.2 a*	7.2 ab
200	70.4 b	7.3 a
300	70.8 ab	7.1 b
C.V.	1.30%	5.93%

*DRMT—Means within same column followed by same letter not considered significantly different at 0.05 level of probability.

The number of days required to reach the flowering stage was significantly greater at the minimum than at the intermediate level of applied nitrogen, yet there was no significant difference between the minimum and maximum nitrogen rates, although the difference in flowering date did approach significance. It has been generally known that nitrogen fertilization hastens flowering of the corn plant.

The means for number of days to ½-silk in all possible combinations of hybrids and populations are given in Table 8. A longer period of time was required for Coker 74 to reach the silk stage at the two denser plantings than at the minimum population. Funk G-4949 produced silks in less time at 15,000 plants per acre than at either of the other three higher populations. The silking date of Pioneer brand 3009 was

Table 8.—Mean number of days from planting to ½-silk of three corn hybrids at four population densities averaged over levels of applied nitrogen

Hybrid	Population, thousands plants/acre 15.0	20.5	25.0	29.0
	-Days to ½-silk, number-			
Coker 74	B[1] 71.2 a[2]	AB 71.8 a	A 72.3 a	A 72.3 a
Funk G-4949	B 71.4 a	A 72.4 a	A 72.5 a	A 72.6 a
Pioneer brand 3009	A 68.5 b	A 68.2 b	A 68.3 b	A 68.3 b

[1] DMRT—Means within same *row* preceded by same *capital* letter not considered significantly different at 0.05 level of probability.

[2] DMRT—Means within same *column* followed by same *small* letter not considered significantly different at 0.05 level of probability.

not significantly influenced by plant density. In addition, Pioneer brand 3009 silked earlier than Coker 74 and Funk G-4949 at each of the population levels. Coker 74 and Funk G-4949 did not differ significantly in time required to reach the silk stage at any of the four planting rates.

Plant height was not affected significantly by population density. Nitrogen effects and hybrid differences in plant height were significant at the 0.01 level of probability. The mean plant heights at the three levels of applied nitrogen averaged over populations and hybrids are reported in Table 7. Plant height at the 200-pound rate of nitrogen was significantly greater than at the 300-pound rate; no significant difference in plant height was evidenced between 100 and 200 pounds of nitrogen. Nitrogen rates did not significantly influence the height of ear.

Hybrid means for plant and ear heights are given in Table 9. The hybrids Funk G-4949 and Pioneer brand 3009 both produced significantly taller plants than did Coker 74; all three hybrids differed significantly in ear height, with Funk G-4949 exhibiting the highest and Pioneer brand 3009 showing the lowest ear placement. The ratio of plant height to ear height in corn hybrids is of interest to those producers who ensile

Table 9.—Mean heights of plant and ear of three corn hybrids averaged over population densities and levels of applied nitrogen

Hybrid	Plant height, feet	Ear height, feet	Plant to ear-height ratio
Funk G-4949	7.3 a*	3.5 a	2.09
Pioneer brand 3009	7.3 a	3.2 c	2.28
Coker 74	7.0 b	3.4 b	2.06
C.V.	5.93%	8.66%	

*DMRT—Means within same column followed by same letter not considered significantly different at 0.05 level of probability.

high-energy forage. In this practice, the stalks are cut just below the ear level so that the proportion of grain in the silage is increased over that of corn silage in which the stalks are cut near the soil. From the viewpoint of high-energy silage, it appears that Funk G-4949 and Coker 74 may be superior to Pioneer brand 3009 because of their lower plant to ear-height ratios (Table 9).

Population density did not significantly affect plant height, but it did influence ear height. Mean ear heights of the four plant densities are listed in Table 10. Ear height was greatest with 29,000 plants per acre. The next highest ear placement occurred at the 25,000-plant level. There was no difference in ear height between the two lowest planting rates.

Table 10.—Mean ear heights at four population densities averaged over levels of applied nitrogen and hybrids

Population, plants/acre, thousands	Ear height, feet
15.0	3.3 c*
20.5	3.3 c
25.0	3.4 b
29.0	3.5 a

*DMRT—Means followed by same letter not considered significantly different at 0.05 level of probability.

Percent Plant Components in Forage

The percentages of stems, cobs, and husks in forage were significantly affected by all treatment variables. Percent leaves in the dry forage did not reflect a nitrogen effect, and percent grain was not significantly influenced by population density. Population × hybrid interactions were significant for percentages of all the plant components except husks; none of the other interactions were significant.

Mean percentages of four plant components, stems, grain, cobs, and husks, in the dry forage at three levels of applied nitrogen are reported in Table 11. The coefficients of variability were reasonably low, indicating a fair degree of accuracy in measuring these properties. Percent stems was significantly greater at the minimum nitrogen rate, and no significant difference existed between the 200- and-300 pound levels. The increase in nitrogen rate from 100 to 200 pounds resulted in a significant increase in percent grain in the dry forage; the third increment of nitrogen did not significantly affect the ratio of grain to vegetative parts of the plant. Percentages of cobs and husks in the forage were significantly higher at the maximum level of applied nitrogen than at the two lower rates. Recognizing that the grain segment of silage is the most digestible of all plant components and that a high ratio of grain to vegetative parts is desirable for quality silage, the 200-pound rate of nitrogen was most favorable, because at that level of fertilization the percentage of grain was at the maximum and percentages of stems and cobs, the least digestible components, were near the minimum.

Table 11.—Mean percent stems, grain, cobs, and husks in dry forage at three levels of applied nitrogen averaged over population densities and hybrids

Applied nitrogen, pounds/acre	Stems, %	Grain, %	Cobs, %	Husks, %
100	26.26 a*	27.18 b	10.35 b	11.66 b
200	24.21 b	29.30 a	10.40 b	12.26 b
300	23.83 b	28.11 ab	10.79 a	13.25 a
C.V.	10.24%	16.39%	11.82%	16.76%

*DMRT—Means within same column followed by same letter not considered significantly different at 0.05 level of probability.

The percentages of grain and husks in dry forage of the three hybrids arc shown in Table 12. Pioneer brand 3009 was superior in percent grain, while Funk G-4949 produced forage with the lowest percent husks. Coker 74 and Funk G-4949 did not differ significantly in percent grain, nor did Pioneer brand 3009 and Coker 74 differ in percent husks. It appears, from the standpoint of digestibility of the silage, that Pioneer brand 3009 probably would be favored over the two other hybrids for silage production because of its higher ratio of grain to vegetative components. This hybrid also produced forage with the highest dry matter percent and was not exceeded in forage yield by either of the two other hybrids.

Table 12.—Mean percent grain and husks in dry forage of corn hybrids averaged over population densities and levels of applied nitrogen

Hybrid	Grain, %	Husks, %
Pioneer brand 3009	30.60 a*	12.51 a
Coker 74	26.84 b	12.79 a
Funk G-4949	27.15 b	11.88 b
C.V.	16.39%	16.76%

*DMRT—Means within same column followed by same letter not considered significantly different at 0.05 level of probability.

Percent husks in the dry forage was affected significantly by population density, and data in Table 13 show that percent husks decreased as the population was increased. The extremes in percent husks were 14.20 at 15,000 plants and 11.03 at 29,000 plants per acre. There was no significant difference in husk content of the forage between the two intermediate planting rates. This negative relationship between percent husks in the forage and population level is in agreement with that reported by others.

Table 13.—Mean percent husks in dry forage at four population densities averaged over levels of applied nitrogen and hybrids

Population, plants/acre, thousands	Husks, %
15.0	14.20 a*
20.5	12.31 b
25.0	12.04 b
29.0	11.03 c

*DMRT—Means followed by same letter not considered significantly different at 0.05 level of probability.

Significant population × hybrid interactions occurred in the expression of forage composition for four plant components, leaves, stems, grain, and cobs. Presented in Table 14 are mean values of percent leaves, stems, grain, and cobs in forage of the three hybrids at four population densities averaged over levels of applied nitrogen.

Planting rate had no significant effect on the proportion of leaves in the dry forage of Pioneer brand 3009. The ratio of stems to the other plant components of this hybrid did not differ among the 15,000-, 20,500-, and 25,000-plant levels, but the ratio increased significantly with the highest population density. The percent grain in forage of Pioneer brand 3009 was significantly higher at the two intermediate populations than at the minimum or maximum population. Percent cobs was significantly less at 29,000 plants per acre than at the two lowest populations, a difference of approximately 1.35 percent.

There were no significant differences in percent stems, grain, or cobs in forage of Funk G-4949 among the four populations. Leaf content of the forage of Funk G-4949 increased significantly with the first increment of increase in population, from 23.42 to 25.36 percent; no significant differences were evidenced above the 20,500-plant level, yet the percent leaves was numerically higher at each successive denser population. Percent grain in Funk G-4949 forage ranged from 26.98 at the minimum population to 27.68 at the maximum planting rate, but the difference was not statistically significant.

Percent leaves and stems in the dry forage of Coker 74 differed significantly between the lowest and highest populations, with the proportion of each being greater at the maximum population density. Coker

Table 14.—Mean percentages of leaves, stems, grain, and cobs in dry forage of three corn hybrids at four population densities averaged over levels of applied nitrogen

	Population, thousands plants/acre							
	15.0	20.5	25.0	29.0	15.0	20.5	25.0	29.0
Hybrid	Leaves, %				Stems, %			
Pioneer brand 3009	A[1] 20.67 b[2]	A 20.62 b	A 21.64 c	A 22.18 b	B 23.56 b	B 22.42 b	B 22.70 b	A 25.74 a
Funk G-4949	B 23.42 a	A 25.36 a	A 25.40 b	A 26.20 a	A 25.53 a	A 26.93 a	A 26.62 a	A 26.36 a
Coker 74	C 23.77 a	B 25.37 a	A 27.32 a	A 27.52 a	B 23.07 b	AB 23.94 b	AB 24.49 b	A 25.88 a
	Grain, %				Cobs, %			
Pioneer brand 3009	B 29.10 a	A 32.36 a	A 31.68 a	B 29.25 a	A 12.56 a	A 12.36 a	AB 11.87 a	B 11.17 a
Funk G-4949	A 26.98 a	A 26.67 b	A 27.27 b	A 27.68 ab	A 10.03 b	A 9.38 c	A 9.22 b	A 9.47 b
Coker 74	A 28.02 a	A 27.27 b	A 26.20 b	A 25.88 b	A 10.72 b	A 10.41 b	B 9.48 b	B 9.52 b

[1] DMRT—Means of one variable within same *row* preceded by same *capital* letter not considered significantly different at 0.05 level of probability.

[2] DMRT—Means of one variable within same *column* followed by same *small* letter not considered significantly different at 0.05 level of probability.

74 showed no effect of population on the proportion of grain in the forage, but the percentage of cobs was significantly lower at 25,000 and 29,000 plants than at the 15,000- and 20,500-plant levels.

A comparison of hybrids within population densities reveals that, at all four population levels, the percent leaves in dry forage of Coker 74 and Funk G-4949 was significantly higher than that of Pioneer brand 3009. At 25,000 plants per acre, forage of Funk G-4949 had a significantly lower leaf percent than did Coker 74 forage. Mean percentages of leaves varied from a low of 20.62 in Pioneer brand 3009 at 20,500 plants to a high of 27.52 in Coker 74 at the maximum population.

Funk G-4949 produced forage with a higher ratio of stems than did the two other hybrids at the three lowest population densities. There was no significant difference in percent stems in forage of the three hybrids at 29,000 plants per acre. Stem percentages ranged from 22.42 in forage of Pioneer brand 3009 at 20,500 plants to 26.93 in Funk G-4949 forage at the same population. All three hybrids produced forage with approximately 26.00 percent stems at the maximum population level.

The ratio of grain to vegetative-plant parts did not differ among hybrids at the minimum population density. However, at each of the three higher planting rates, Pioneer brand 3009 silage consisted of a significantly greater proportion of grain than did silage of the two other hybrids. The percent grain in dry forage varied from a high of 32.36 for Pioneer brand 3009 at 20,500 plants to a low of 25.88 for Coker 74 at 29,000 plants. Mean values for percent grain in dry forage of the three hybrids, Pioneer brand 3009, Funk G-4949, and Coker 74, were 30.60, 27.15, and 26.84, respectively.

From the standpoint of forage composition by plant components, Pioneer brand 3009 had the highest percentage of grain (the most digestible fraction), a low percentage of stems (the least digestible segment), and high percentages of cobs and husks, both of which are intermediate in digestibility, and was low in percent leaves. Funk G-4949 was intermediate in percent grain and leaves, high in percent stems and husks, and low in percent cobs. Coker 74 was low in percent grain, stems, and husks, high in percent leaves, and intermediate in percent cobs.

Correlation Coefficients

Table 15 contains simple correlation coefficient values involving the variables percent dry matter, forage yield, plant and ear heights, silking date, and percentages of five plant components in dry forage.

Percent dry matter was positively correlated, at the 0.01 level of probability, with dry forage yield, plant and ear heights, and percent grain and cobs. Highly significant negative associations occurred between percent dry matter and number of days to ½-silk, percent leaves, and percent husks in the forage. There was no apparent relationship between percent dry matter and green forage yield or percent stems in the

Table 15.—Correlation coefficients among the variables percent dry matter, forage yield, plant height, ear height, number of days to ½-silk, and percent leaves, stems, grain, cobs, and husks in dry forage

Variable	Green forage yield	Dry forage yield	Plant height	Ear height	No. days to ½-silk	Leaves, %	Stems, %	Grain, %	Cobs, %	Husks, %
Dry matter, %	0.091	0.374**	0.256**	0.141**	-0.309**	-0.254**	-0.063	0.248**	0.298**	-0.263**
Green forage yield		0.867**	0.277**	0.387**	-0.406**	-0.047	-0.252**	0.271**	0.146**	-0.186**
Dry forage yield			0.310**	0.357**	-0.427**	-0.094**	-0.235**	0.297**	0.203**	-0.245**
Plant height				0.496**	0.298**	0.353**	-0.065	-0.109*	-0.126**	-0.095*
Ear height					-0.001	0.059	0.199**	-0.102*	-0.205**	-0.091
No. days to ½-silk						0.589**	0.388**	-0.621**	-0.524**	0.243**
Leaves, %							0.005	-0.479**	-0.479**	-0.140**
Stems, %								-0.742**	-0.453**	0.153**
Grain, %									0.388**	-0.460**
Cobs, %										0.030

*Denotes significance at 0.05 level of probability.
**Denotes significance at 0.01 level of probability.

forage. Between 6.00 and 9.00 percent of the variation in percent dry matter was accounted for by differences in percentages of grain, leaves, cobs, and husks, and by differences in plant height.

Green forage yield was associated in a highly significant positive manner with dry yield, plant and ear heights, and percent grain and cobs in the forage. As expected, the closest relationship existed between green and dry forage yields. Negative correlations, with significance at the 0.01 level of probability, were found between green yield and number of days to ½-silk and percent stems and husks in the forage. No association was evidenced between green yield and percent leaves in the forage.

Dry forage yield was positively associated, at the 0.01 level of probability, with plant and ear heights, and with percentages of grain and cobs in the forage. The negative correlations between dry yield and number of days to ½-silk and percent leaves, stems, and husks in the forage were highly significant. Differences in plant and ear heights each accounted for about 10 percent, differences in number of days to ½-silk about 18 percent, and differences in plant composition of stems, grain, cobs, and husks, each about 7 percent of the variation in dry forage yield. Of the properties studied, tall plant height and high percent grain in the forage had the most favorable influence on dry forage yield. Lateness of flowering appeared to be detrimental to forage yield, both green and dry, but the negative relationship indicated between the two probably was due more to the hybrid than to silking date because the latest flowering hybrid was the poorest forage yielder.

Plant height was positively correlated with ear height, as expected, with flowering date, and with percent leaves in the forage. Very small, but significant, negative associations were shown between plant height and percentages of grain, cobs, and husks in the forage. Surprisingly, there was no relationship between plant height and stem composition of the forage. The larger amount of stem material in tall plants apparently was more than offset by the increased proportion of leaves to total-plant parts, as suggested by the relatively high, positive correlation between plant height and percent leaves.

Silking date was positively associated with percentages of leaves, stems, and husks, but was negatively correlated with percent grain and cobs in the forage. The later flowering plants produced forage with proportionally higher contents of leaves, stems, and husks and a lower composition of grain and cobs.

Highly significant, negative relationships were evidenced for both percent leaves and percent stems with both percent grain and percent cob in the dry forage. Those factors which contributed to increased percentages of leaves and stems caused corresponding reductions in percent grain and cobs in the forage. Based on the size of the correlation coefficients, it appears that percent grain, the most digestible of corn silage components, could be increased most effectively by reducing the proportion of stems in the forage. Results of the study indicate that this may be possible through wise selection of the corn hybrid to be grown, by restricting the population density to a maximum of 25,000 plants per acre, and by fertilizing with approximately 200 pounds of nitrogen.

Percent grain was positively associated with percent cobs and negatively related to percent husks in the forage. As the proportion of grain increased in the forage, the proportion of cobs also increased, but the proportion of husks decreased. There was no measurable relationship between percent cobs and percent husks in the forage.

SUMMARY

Both forage and grain yields were affected significantly by all three treatment variables, population density, level of applied nitrogen, and hybrid. Maximum yields of forage were obtained from a combination of 25,000 plants per acre and 200 pounds of applied nitrogen with each of the three hybrids. Grain yields of Pioneer brand 3009 and Funk G-4949 were superior to that of Coker 74; the two superior hybrids responded to a population level of 25,000 plants and a 200-pound nitrogen application.

Percent dry matter in the forage was influenced significantly by planting rate, nitrogen level, and hybrid. Dry matter percentage behaved in an erratic manner as population density changed, was significantly reduced by increases in levels of applied nitrogen, and varied significantly among hybrids, with Pioneer brand 3009 forage containing the least water and Coker 74 containing the most.

Silking date of two of the three hybrids was delayed by an increase in population density; nitrogen fertilization tended to hasten flowering. Plant height was influenced very little by added nitrogen. Ear height increased as the population level was increased.

Forage composition by plant component was affected significantly by the three treatment variables. Percent leaves and stems in the forage increased with population increases, in contrast to the percent cobs and husks, which decreased. The grain fraction of two hybrids was not influenced proportionately by changes in population density. There was no significant effect of nitrogen on the ratio of leaves to the other plant components. Percent stems in the forage was at a maximum at the 100-pound level of applied nitrogen, while percentages of cobs, grain, and husks were higher at the higher nitrogen rates.

Pioneer brand 3009 produced forage having the highest percentage of grain (the most digestible fraction of silage), a low percentage of stems (the least digestible component), and high percentages of cobs and husks, both of which are intermediate in digestibility. Funk G-4949 forage was intermediate in percent grain and leaves, high in percent stems and husks, and low in percent cobs. Forage from Coker 74 was low in percent grain and husks, high in percent leaves, and intermediate in percent cobs.

Dry forage yield was positively correlated with green forage yield, with percent dry matter, with plant and ear heights, and with percent grain and cobs.

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Effects of Hybrid, Population Density, and Nitrogen Level on Corn Forage Under Irrigation on Grenada Soil

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INTRODUCTION

Dairymen farming on the Macon Ridge, an area of Mississippi Terrace soils in Northeast Louisiana, traditionally experience difficulty in producing satisfactory yields of corn (*Zea mays* L.) silage because of unfavorable soil moisture conditions which prevail almost every growing season. No research has been conducted in that area of the state on the cultural practices that are necessary for the economic production of corn silage. In order to provide pertinent information to interested farmers, a four-year project was initiated in 1969 at the Macon Ridge Branch (Winnsboro) of the Northeast Louisiana Experiment Station to evaluate the response of three full-season corn hybrids to different population densities and levels of applied nitrogen with irrigation on Grenada silt loam soil.

REVIEW OF LITERATURE

Corn silage is a superior feed for milk production with dairy cows. Ellzey (*6*)[8] compared corn silage with a dairy ration containing millet silage supplemented by crushed corn and with forage sorghum silage. Milk production from corn silage exceeded that of the millet silage plus supplement and the forage sorghum silage by 7.5 percent and 6.5 percent, respectively. Quality is determined to a great extent by the proportion of grain to vegetative components in corn silage. In a study involving several corn hybrids grown at 22,000 plants per acre in Georgia, Cummins et al. (*3*) found that the dry forage averaged 55 percent ears, 20 percent leaves, and 28 percent stalks. Plant population did not influence the plant-component composition of corn silage, according to Genter and Camper (*7*). Lutz et al. (*10*) also reported that the ear-to-stover ratio in corn silage was not significantly altered by population density. In Alabama, increases in the ratio of ears to plant weight accompanied denser plantings (*5*). Bryant and Blaser (*1*), in Virginia, noted a decrease in the proportion of husks in corn forage as the planting rate increased.

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[8] Italic numbers in parentheses refer to Literature Cited, page 16.

Nitrogen application reportedly has affected the plant-component composition of corn forage. In Georgia, Cummins (*2*) increased the proportion of ears, decreased the proportion of stalks, and failed to change the proportion of leaves in corn forage by the addition of 50 pounds of nitrogen per acre. As noted by Cummins et al. (*3*), corn hybrids differed in plant-component composition of forage, with ranges in percentages of ears, stalks, and leaves of 44 to 66, 20 to 36, and 14 to 25, respectively.

In regard to silage quality, Gordon et al. (*9*) reported that corn silages cut at 28 percent dry matter and at 60 percent dry matter did not differ in feed value when fed to lactating dairy cows.

Bryant and Blaser (*1*) found a linear relationship between silage yield and plant population up to a density of 98,000 plants per hectare (39,675 per acre). Corn silage yield in Virginia (*7*) increased with increases in population to the 64,200-plant-per-hectare level (26,000 per acre), and in Alabama (*5*) yield response continued to the 74,000-plant-per-hectare density (30,000 per acre). Robinson and Murphy (*12*), employing irrigation at five locations in Kansas, found that forage yield was not significantly affected by population density, which ranged from a low of 29,500 plants per hectare (11,940 per acre) to 98,800 per hectare (40,000 per acre).

Cummins (*2*) reported increases in both green and dry forage yields from the application of nitrogen up to 150 pounds per acre. An increase in dry matter yield was obtained in Wisconsin by Gonske and Keeney (*8*) from 100 kg of applied nitrogen per hectare (90 pounds per acre), but there were no further increases in yield above that level of nitrogen fertilization. Vandersall et al. (*13*) found that nitrogen fertilization increased the dry matter yield of corn silage, but the use of nitrogen had no effect on forage intake or milk production of dairy cows. Robinson and Murphy (*12*) stated that forage yield was increased by nitrogen application in Kansas.

More than 10 tons of dry corn forage per acre was produced in Colorado with 300 pounds of nitrogen, 28,000 plants per acre, and irrigation (*4*). From a five-year study in Louisiana, Phillips (*11*) observed corn grain yield increases of 27 percent from irrigation with 120 pounds of applied nitrogen per acre and 39 percent with 180 pounds of nitrogen.

EXPERIMENTAL PROCEDURE

The three corn hybrids, Coker 74, Funk G-4949, and Pioneer brand 3009, utilized in the study were full-season corns adapted to the area for grain production. Population densities of approximately 15,000, 20,500, 25,000, and 29,000 plants per acre were obtained by using single-plant hill spacings of 11.5, 8.5, 7.0, and 6.0 inches, respectively, in 36-inch rows.

Three levels of nitrogen, 100, 200, and 300 pounds per acre, were applied annually. The factors, hybrids, population densities, and levels of added nitrogen, were included in all possible combinations. A split-split plot arrangement in a randomized block design with three replications was employed to statistically evaluate treatment differences.

Ammonium nitrate (33.5 percent N) served as the nitrogen source. The nitrogen, 200 pounds of P_2O_5, and 250 pounds of K_2O per acre were broadcast by hand and disced into the soil to a depth of approximately 4 inches. All fertilizers were applied prior to planting each year.

Plots were hand planted and thinned to the desired stand at the post-seedling stage. Missing hills were compensated for by leaving two plants in hills adjacent to the skip so that near perfect stands resulted. The test was planted in the first or second week of April in each of the four years. A broadcast treatment of 2.5 pounds of Aatrex 80 W per acre was applied immediately after planting.

The test area was furrow irrigated from two to five times annually with 2 acre-inches of water per irrigation. In three of the four years, water was applied at approximately 8-day intervals; the exception was in 1970, when the plots were irrigated twice, on May 26 and July 9.

Each plot consisted of three rows 15 feet in length. The center row of the plot was harvested for silage evaluation; one plant on each end of the plot row was not harvested in order to reduce border effects. Dates of harvest occurred in the last two weeks in July each year. The earliest harvest date was July 20 in 1972 and the latest was July 30 in 1970. The number of days from planting to harvest ranged from 100 in 1972 to 115 in 1970.

The stalks were cut by hand approximately 6 inches above the ground after the grain had reached the hard-dough stage of maturity. Total green forage weight was obtained for each plot. At harvest, two samples of five plants each were collected from each plot. One, the whole-plant sample, was used for dry matter determination; the other, referred to as the separation sample, was separated into five plant components, leaves, stems, grain, cobs, and husks, in order to measure the contribution of each plant component to total forage yield. The whole-plant samples were weighed immediately after collection to obtain green weight, then dried to a constant weight in a forage dryer at 150° F. The dried samples were weighed and the green and dry weights were used to compute percent dry matter for each plot.

Composition of the forage by plant component was determined by drying each of the five components from the separation sample. Percentages of plant components in the dry forage were calculated by dividing the dry weight of each component by the total dry weight of all components in that sample and multiplying by 100.

Forage yields are reported in tons per acre on both the green- and the dry-weight basis. Forage composition is presented as percentages of leaves, stems, grain, cobs, and husks. Plant and ear heights and percent stand were also measured. All possible correlation coefficients among the variables were obtained and the effects of the treatments on the variables were evaluated using an analysis of variance.

RESULTS AND DISCUSSION

The data are reported and discussed as four-year averages, 1969-1972.

Yield and Percent Dry Matter

Percent stand had no significant effect on the results of this study. Population density significantly affected forage yield and dry matter percent; in addition, the interaction between population and nitrogen rate was significant for green forage yield.

Mean dry forage yields and dry matter percentages of the four plant densities are reported in Table 1. Yields of dry forage at 25,000 and 29,000 plants per acre were significantly greater than that at 15,000 plants. There were no significant differences among dry yields at 20,500, 25,000, and 29,000 plants per acre. Dry forage tonnages ranged from 5.17 at the minimum population to 6.01 per acre at the maximum population.

The only significant difference in percent dry matter occurred between the 25,000- and 29,000-plant levels with mean percentage values of 28.36 and 29.64 at the two populations, respectively.

Table 1.—Mean yields and dry matter percentages in forage at four population densities averaged over levels of applied nitrogen and hybrids

Population, plants/acre, thousands	Yield, dry forage, tons/acre	Dry matter, %
15.0	5.17 b*	29.12 ab
20.5	5.61 ab	29.13 ab
25.0	5.78 a	28.36 b
29.0	6.01 a	29.64 a
C.V.	15.97%	9.89%

*DMRT (Duncan's Multiple Range Test)—Means within columns followed by same letter are not significantly different at 0.05 level of probability.

Forage yield and percent dry matter were influenced significantly by levels of applied nitrogen. Included in Table 2 are the means for dry forage yield and percent dry matter at the three nitrogen rates averaged over population densities and hybrids. The dry yields at the 200- and 300-pound rates were significantly greater than that at 100 pounds per acre, with no difference between the two highest levels of applied nitrogen. Dry yield was increased nearly one-third ton per acre from the second increment of nitrogen fertilization.

Mean percent dry matter was significantly reduced by the application

Table 2.—Mean yields and dry matter percentages in forage at three levels of applied nitrogen averaged over population densities and hybrids

Applied nitrogen, pounds/acre	Yield, dry forage, tons/acre	Dry matter, %
100	5.44 b*	30.05 a
200	5.73 a	28.81 b
300	5.75 a	28.83 b

*DMRT—Means within columns followed by same letter are not significantly different at 0.05 level of probability.

of 200 pounds of nitrogen, from 30.05 at the 100-pound rate to 28.81 at the 200-pound level. Fertilizing with additional nitrogen did not result in a further reduction in dry matter content of the forage.

Hybrids differed significantly in green and dry yields and in percent dry matter. Mean values of these three variables for each of the hybrids are reported in Table 3. Funk G-4949 produced significantly more green forage than either of the two other hybrids; Coker 74 was the poorest yielder of forage, both green and dry. The dry forage yields of Funk G-4949 and Pioneer brand 3009 did not differ. Green yields ranged from 20.34 to 18.69 tons per acre while the maximum and minimum dry yields were 5.89 and 5.19 tons, respectively.

Forage of Pioneer brand 3009, with 30.38 percent dry matter, significantly exceeded that of Funk G-4949 (29.01 percent). Coker 74 forage had the lowest dry matter content at 27.79 percent.

Table 3.—Mean yields and dry matter percentages in forage of three hybrids averaged over population densities and levels of applied nitrogen

Hybrid	Yield, green forage, tons/acre	Yield, dry forage, tons/acre	Dry matter, %
Funk G-4949	20.34 a*	5.89 a	29.01 b
Pioneer brand 3009	19.35 b	5.85 a	30.38 a
Coker 74	18.69 c	5.19 b	27.79 c
C.V.	11.14%	15.97%	9.89%

*DMRT—Means within columns followed by same letter are not significantly different at 0.05 level of probability.

Presented in Table 4 are the mean green forage yields for all combinations of population densities and nitrogen rates averaged for hybrids. At the minimum plant density, yields for the three levels of applied nitrogen did not differ significantly, although the range was from 17.26 to 18.39 tons per acre. Yield at the 300-pound rate was superior to yields at the first two increments of nitrogen with 20,500 plants. The 25,000-plant density produced significantly less green forage with 100 pounds of nitrogen than with either 200 or 300 pounds; the two highest levels of nitrogen fertilization did not differ in green yield at that planting rate. At the maximum population density, the only significant difference in green forage yield occurred between the first and second increments of nitrogen application, with the 200-pound level yielding more.

Mean yields of green forage did not differ significantly among population densities at the minimum nitrogen rate. With the second increment of nitrogen fertilization, the green yield at 25,000 plants was significantly greater than that at 15,000 plants per acre. At the maximum level of nitrogen application, yields of the three densest plantings all exceeded that of 15,000 plants.

Table 4.—Mean forage yields at four population densities and three levels of applied nitrogen averaged for hybrids

Population, plants/acre, thousands	Applied nitrogen, pounds/acre		
	100	200	300
	Yield, green forage, tons/acre		
15.0	A[1] 17.26 a[2]	A 18.39 b	A 17.94 b
20.5	B 17.13 a	B 19.14 ab	A 21.27 a
25.0	B 18.46 a	A 21.42 a	A 21.39 a
29.0	B 19.21 a	A 21.05 ab	AB 20.85 a

[1] DMRT—Means within same *row* preceded by same *capital* letter are not significantly different at 0.05 level of probability.

[2] DMRT—Means within same *column* followed by same *small* letter are not significantly different at 0.05 level of probability.

Plant and Ear Heights and Forage Composition

The effects of nitrogen rates and hybrids and the population × nitrogen rate interaction on both plant and ear heights were significant. Reported in Table 5 are the hybrid mean values of plant height and ear height averaged over population densities and levels of applied nitrogen.

Funk G-4949 produced the tallest plants with the highest ear placement. Plant height of Coker 74 and ear placement of Pioneer brand 3009 were lowest of the three hybrids.

Table 5.—Mean heights of plants and ears of three hybrids averaged over population densities and levels of applied nitrogen

Hybrid	Plant height, feet	Ear height, feet
Funk G-4949	7.5 a*	4.1 a
Pioneer brand 3009	7.4 b	3.8 c
Coker 74	7.2 c	4.0 b
C.V.	4.17%	7.79%

*DMRT—Means within same column followed by same letter are not significantly different at 0.05 level of probability.

Mean heights of plants and ears at the four population densities and three levels of applied nitrogen averaged for hybrids are given in Table 6. Neither plant heights nor ear heights differed significantly among nitrogen rates at 15,000, 20,500, and 29,000 plants per acre. Plant height at 25,000 plants was significantly greater with 200 pounds of nitrogen than at the other nitrogen levels. Ear placement was significantly lower for 25,000 plants at 100 pounds of nitrogen than at the two highest nitrogen rates, with no significant difference between the two highest rates.

Table 6.—Mean heights of plants and ears at four population densities and three levels of applied nitrogen averaged for hybrids

Population, plants/acre, thousands	Applied nitrogen, pounds/acre					
	100	200	300	100	200	300
	Plant height, feet			Ear height, feet		
15.0	A[1] 7.2 ab[2]	A 7.3 a	A 7.2 a	A 3.9 ab	A 3.9 a	A 3.9 a
20.5	A 7.4 ab	A 7.4 a	A 7.5 a	A 3.8 ab	A 3.9 a	A 4.0 a
25.0	B 7.1 b	A 7.6 a	B 7.3 a	B 3.7 b	A 4.2 a	A 4.0 a
29.0	A 7.5 a	A 7.5 a	A 7.5 a	A 4.1 a	A 4.2 a	A 4.2 a

[1] DMRT—Means for each variable within same *row* preceded by same *capital* letter are not significantly different at 0.05 level of probability.

[2] DMRT—Means within same *column* followed by same *small* letter are not significantly different at 0.05 level of probability.

Population effects were significant for the proportion of leaves, stems, cobs, and husks but not for percent grain in the forage. Reported in Table 7 are the percentages of leaves, stems, cobs, and husks in dry forage for the four population densities averaged over levels of applied nitrogen and hybrids.

Percent leaves in the forage was significantly greater at the maximum than at the minimum population level. Populations of 20,500, 25,000, and 29,000 plants produced silage with significantly more stems in proportion

Table 7.—Mean percent leaves, stems, cobs, and husks in dry forage at four population densities averaged over levels of applied nitrogen and hybrids

Population, plants/acre, thousands	Leaves, %	Stems, %	Cobs, %	Husks, %
15.0	22.91 b*	24.30 b	10.99 a	13.14 a
20.5	24.02 ab	25.84 a	10.52 ab	11.15 b
25.0	23.96 ab	25.81 a	10.28 ab	11.24 b
29.0	24.97 a	25.64 a	10.05 b	9.92 c
C.V.	13.74%	12.28%	17.08%	20.33%

*DMRT—Means within same column followed by same letter are not significantly different at 0.05 level of probability.

to other plant parts than did the 15,000-plant population. Percent cobs decreased significantly as the population increased from 15,000 to 29,000 plants. Fifteen thousand plants per acre yielded silage containing the greatest proportion of husks, while silage of 29,000 plants was significantly lowest in percent husks. It is evident from these data that increasing the planting rate tended to increase the percentages of leaves and stems and reduce the proportions of cobs and husks in the forage.

Percent leaves, stems, grain, and husks in the forage were affected significantly by nitrogen rates. Also, there was a significant nitrogen rate × hybrid interaction for content of stems and grain but not for percentages of leaves and husks in the forage. Included in Table 8 are mean values of percent leaves and percent husks in forage for the three levels of applied nitrogen. Increasing the nitrogen application from 100 to 300 pounds per acre significantly lowered the percent leaves and raised the percent husks in forage. Nitrogen fertilization altered the plant-component composition of forage by decreasing the proportion of leaves and increasing the proportion of husks.

Table 8.—Mean percent leaves and husks in dry forage at three levels of applied nitrogen averaged over population densities and hybrids

Applied nitrogen, pounds/acre	Leaves, %	Husks, %
100	24.64 a*	10.69 b
200	23.76 ab	11.37 ab
300	23.50 b	12.04 a

*DMRT—Means within same column followed by same letter are not significantly different at 0.05 level of probability.

Forage of the hybrids differed significantly in percentages of all five plant components, and there were significant nitrogen × hybrid interactions for percent stems and grain. Hybrid means for percent leaves, cobs, and husks in dry forage are given in Table 9.

Coker 74 forage was highest, that of Pioneer brand 3009 was lowest, and Funk G-4949 forage was intermediate in percent leaves. Percent cobs was greatest in forage of Pioneer brand 3009, least in Funk G-4949

Table 9.—Mean percent leaves, cobs, and husks in dry forage of hybrids averaged over population densities and levels of applied nitrogen

Hybrid	Leaves, %	Cobs, %	Husks, %
Coker 74	25.62 a*	10.24 b	12.09 a
Funk G-4949	24.39 b	9.06 c	11.03 b
Pioneer brand 3009	21.88 c	12.09 a	10.97 b

*DMRT—Means within same column followed by same letter are not significantly different at 0.05 level of probability.

forage, and intermediate in Coker 74 forage. Coker 74 produced forage with a significantly higher percentage of husks than the two other hybrids. Ranges in percent leaves, cobs, and husks among hybrids were 21.88 to 25.62, 9.06 to 12.09, and 10.97 to 12.09, respectively.

Interactions between nitrogen rates and hybrids for percent stems and percent grain are evidenced by data in Table 10. Proportions of neither component in the forage of Funk G-4949 were significantly altered by nitrogen fertilization. Forage of Funk G-4949 averaged 27.48 percent stems and 28.11 percent grain. Percent stems of Coker 74 forage was significantly higher at the minimum level of nitrogen than at the two higher rates; the grain percent was significantly lowest at 100 pounds of nitrogen. Coker 74 forage contained an average of 24.11 percent stems and 27.95 percent grain. Pioneer brand 3009 forage had a significantly higher percentage of stems at the minimum than at the intermediate nitrogen level. Nitrogen application did not significantly affect the proportion of grain in forage of Pioneer brand 3009. Averages of 24.54 percent stems and 30.53 percent grain existed in Pioneer brand 3009 forage.

Comparisons of hybrids within nitrogen rates show that Funk G-4949 forage was significantly higher in percent stems than forage of Pioneer brand 3009 at the two lowest levels of nitrogen. Percent stems in Coker 74 forage did not differ significantly from that of Pioneer brand 3009 at the minimum and intermediate nitrogen levels; however, the proportion of stems in forage of Coker 74 was significantly lower than in forages of the other two hybrids at maximum nitrogen fertilization.

At the 100-pound nitrogen level, percent grain in the forages of Funk G-4949 and Pioneer brand 3009 did not differ significantly, but both were significantly higher than that of Coker 74. Pioneer brand 3009 forage at 200 pounds of nitrogen had a significantly greater percentage of grain than did forage of Funk G-4949. There were no significant differences in the proportion of grain in forage of the three hybrids at the maximum level of nitrogen fertilization.

Table 10.—Mean percent stems and grain in dry forage of three corn hybrids at three levels of applied nitrogen averaged for population densities

	Applied nitrogen, pounds/acre					
	100	200	300	100	200	300
Hybrid	Stems, %			Grain, %		
Funk G-4949	A[1] 27.32 a[2]	A 27.68 a	A 27.43 a	A 28.19 a	A 28.07 b	A 28.06 a
Coker 74	A 26.34 ab	B 23.18 b	B 22.80 b	B 25.39 b	A 29.43 ab	A 29.02 a
Pioneer brand 3009	A 25.42 b	B 23.62 b	AB 24.57 a	A 30.39 a	A 31.32 a	A 29.87 a

[1] DMRT—Means for each variable within same *row* preceded by same *capital* letter are not significantly different at 0.05 level of probability.

[2] DMRT—Means in same *column* followed by same *small* letter are not significantly different at 0.05 level of probability.

The interaction between plant population and nitrogen level was significant for percent grain in dry forage. Mean values of percent grain for all combinations of population density and nitrogen rate averaged for hybrids are given in Table 11. At 25,000 plants per acre, there were no significant differences in mean percent grain among the three nitrogen rates. Grain content of the forage was significantly less, percentagewise, at the minimum nitrogen level than at the two highest rates for 20,500 and 29,000 plants per acre. At 15,000 plants per acre, grain percent of the forage for the intermediate level of fertilization was significantly greater than that for the maximum nitrogen rate.

Percent grain in the forage did not differ among populations at any of the three nitrogen levels.

Table 11.—Mean percent grain in dry forage at four population densities and three levels of applied nitrogen averaged for hybrids

Population, plants/acre, thousands	Applied nitrogen, pounds/acre		
	100	200	300
	Grain in dry forage, %		
15.0	AB[1] 28.92 a[2]	A 29.97 a	B 27.62 a
20.5	B 26.67 a	A 29.97 a	A 28.76 a
25.0	A 28.74 a	A 28.17 a	A 29.22 a
29.0	B 27.63 a	A 30.32 a	A 30.33 a

[1] DMRT—Means within same *row* preceded by same *capital* letter are not significantly different at 0.05 level of probability.

[2] DMRT—Means within same *column* followed by same *small* letter are not significantly different at 0.05 level of probability.

Correlation Coefficients

All possible correlation coefficients among the variables, percent dry matter, green forage yield, dry forage yield, plant height, ear height, and percentages of leaves, stems, grain, cobs, and husks in dry forage, are reported in Table 12.

Percent dry matter was positively correlated with dry forage yield ($P < 0.01$), percent grain ($P < 0.01$), and percent cobs in the forage ($P < 0.05$). About 33 percent of the variation in percent dry matter was attributable to differences in grain content of the forage. Highly significant negative correlations were shown between percent dry matter and plant height, ear height, percent leaves, percent stems, and percent husks. The negative effects on percent dry matter were greatest in the leaf and stem components of the forage. Variations in percent leaves and stems each accounted for about 16 percent of the variation in percent dry matter.

Correlation coefficients involving green forage yield with dry forage yield, plant height, and ear height were highly significant and of great magnitude. Highly significant, positive correlations also were shown

Table 12.—Correlation coefficients among the variables percent dry matter, forage yield, plant and ear heights, and percent leaves, stems, grain, cobs, and husks in dry forage

Variable	Green forage yield	Dry forage yield	Plant height	Ear height	Leaves, %	Stems, %	Grain, %	Cobs, %	Husks, %
Dry matter, %	–0.073	0.408**	–0.132**	–0.327**	–0.399**	–0.398**	0.574**	0.114*	–0.234**
Green forage yield		0.863**	0.800**	0.835**	0.274**	0.171**	0.125**	–0.500**	–0.519**
Dry forage yield			0.646**	0.796**	0.048	–0.054	0.402**	–0.400**	–0.570**
Plant height				0.925**	0.479**	0.443**	–0.148**	–0.521**	–0.577**
Ear height					0.590**	0.503**	–0.311**	–0.610**	–0.557**
Leaves, %						0.522**	–0.631**	–0.560**	–0.298**
Stems, %							–0.762**	–0.386**	–0.202**
Grain, %								0.067	–0.280**
Cobs, %									0.421**

*Denotes significance at 0.05 level of probability.
**Denotes significance at 0.01 level of probability.

between green yield and percentages of leaves, stems, and grain in the forage. Green forage yield was negatively associated ($P < 0.01$) with percent cobs and husks in the forage.

Dry forage yield was positively related to plant and ear heights and percent grain in the forage. Highly significant, negative correlations were shown for dry yield with percent cobs and husks in the forage. There was no apparent association of dry forage yield with either percent leaves or percent stems. Dry yield was affected more by plant height and percent husks in the forage and to a lesser extent by percent grain and percent cobs. Planting a tall-growing hybrid and following practices which would increase the grain content appear to offer the most promise for improving the yield of dry forage in corn silage production.

Plant height was positively correlated ($P < 0.01$) with ear height and percentages of leaves and stems in the forage. Highly significant, negative associations were shown between plant height and percentages of grain, cobs, and husks in dry forage. The small size of the correlation coefficient between plant height and percent grain denotes little association between the two.

The proportion of leaves in the forage was positively correlated with percent stems and negatively correlated with percentages of grain, cobs, and husks. All four correlation coefficients were highly significant. The percent stems increased with increases in percent leaves, but the percentages of grain, cobs, and husks decreased. The latter three mentioned variables were negatively correlated ($P < 0.01$) with percent stems in the forage. About 58 percent of the variation in percent stems was related to differences in percent grain. Since grain is the most digestible and stems are the least digestible of the corn silage fractions, silage quality could be greatly improved by following practices which reduce the stem content of the forage.

Percent husks in the forage was negatively correlated ($P < 0.01$) with percent grain and positively correlated with percent cobs in the forage.

SUMMARY

All three treatment factors, population density, nitrogen rate, and hybrid, influenced forage yield. Production at 25,000 and 29,000 plants was significantly greater than that at 15,000 plants per acre. A significant yield increase accompanied the application of 200 pounds of nitrogen; no further increase occurred from fertilization with additional nitrogen. Funk G-4949 and Pioneer brand 3009 did not differ in dry forage yield, but both were superior to Coker 74 as an average of population densities and nitrogen rates.

Percent dry matter was significantly greatest at the minimum rate of nitrogen fertilization, with no difference between the two highest levels.

Pioneer brand 3009 forage was highest, Coker 74 forage was lowest, and Funk G-4949 forage was intermediate in dry matter content. Mean dry matter percentages for the three hybrids were 30.38, 27.79, and 29.01, respectively.

Percent leaves and stems in dry forage increased significantly and percentages of cobs and husks decreased significantly with the increase in population from 15,000 to 29,000 plants per acre. Nitrogen fertilization tended to reduce the proportion of leaves and increase the proportion of husks in the forage. Percent stems was significantly decreased in two hybrids as the nitrogen rate was increased from 100 to 200 pounds per acre. Pioneer brand 3009 forage was highest in grain (30.52 percent) and cobs (12.09 percent) and lowest in leaves (21.88 percent); forage of Funk G-4949 was highest in stems (27.47 percent) and lowest in cobs (9.06 percent), and Coker 74 forage was highest in leaves (25.62 percent) and husks (12.09 percent).

Dry matter percent was postively correlated with dry yield and with percentages of grain and cobs in the forage. Moderately strong negative associations existed between percent dry matter and percent leaves and stems.

Yield of dry forage was not related to the proportions of leaves and stems but was positively correlated with percent grain in the forage and with plant and ear heights. Differences in plant height and percent grain accounted for 42 and 16 percent, respectively, of the variation in dry forage yield. Increasing the proportion of grain in forage appears to be one means of increasing dry yield.

Correlations between plant height and percent leaves and stems were positive, while plant height was negatively correlated with percent cobs and husks.

Percent leaves in the forage was positively correlated with percent stems and negatively correlated with percentages of grain, cobs, and husks. Stem content was negatively associated with percent grain, cobs, and husks. The sizable negative relationships between percent grain and percentages of stems and leaves suggest that silage quality could be significantly improved by increasing the grain content, the most digestible fraction, which would result in corresponding reductions in percentages of leaves and stems, both of which are less digestible than grain. Based on evidence from this study, silage quality could be improved by wise selection of the hybrid to be grown, fertilizing with approximately 200 pounds of nitrogen, and restricting the population density to 15,000 plants per acre. However, the restriction in population would result in lower yield of forage.

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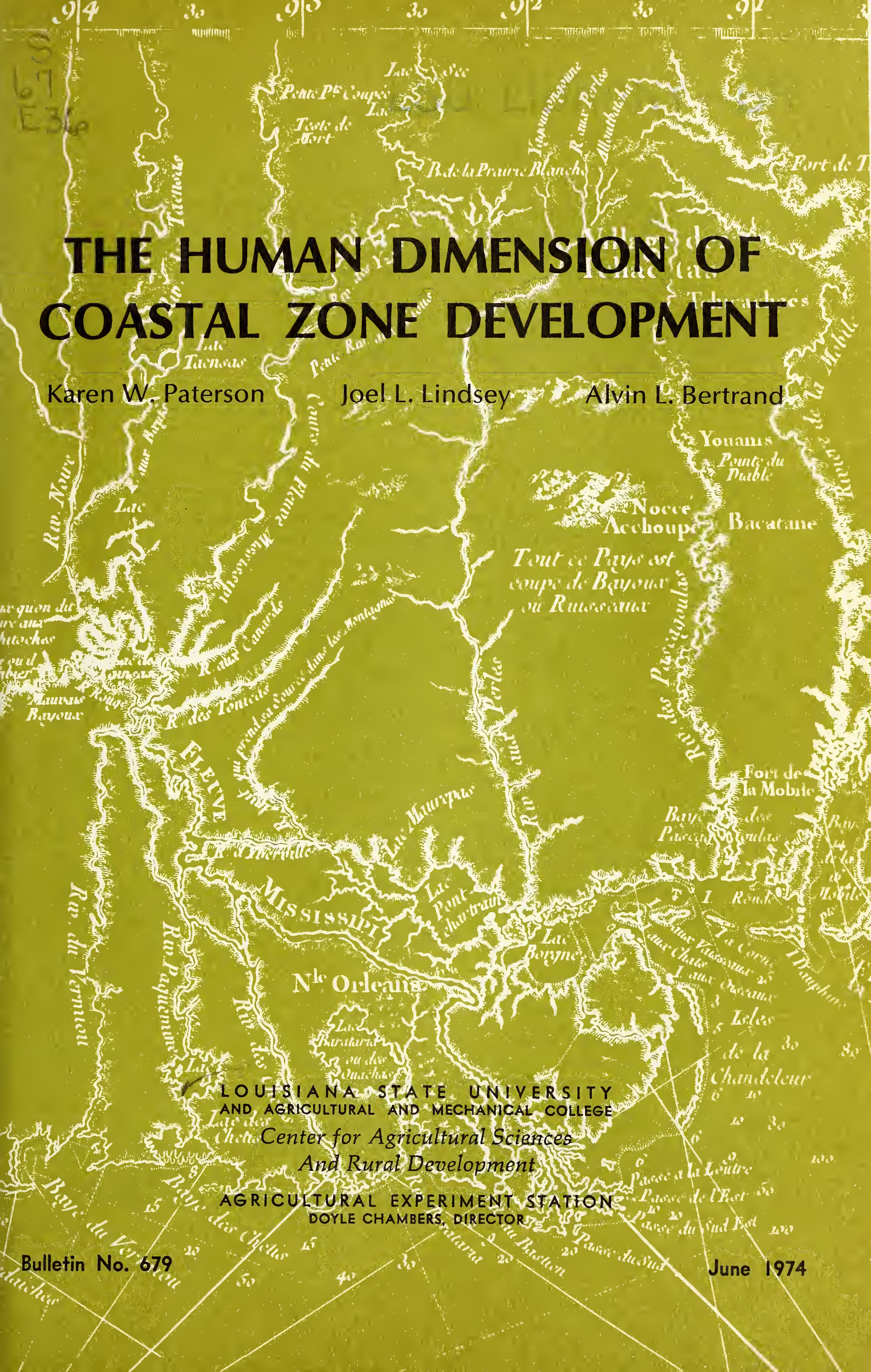

THE HUMAN DIMENSION OF COASTAL ZONE DEVELOPMENT

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The Human Dimension Of Coastal Zone Development

KAREN W. PATERSON, JOEL LINDSEY AND ALVIN L. BERTRAND*

Introduction

This is a time of grave concern over the proper development of our natural resources. The research reported in this bulletin was undertaken in an attempt to develop a greater understanding of the social factors which need to be considered in the formulation of programs and policies for the conservation and management of coastal regions. It is the first phase of an overall project planned to provide background information about residents of coastal areas and the feelings and attitudes of the people of Louisiana about these areas.[1]

Three broad classes of data were researched and are described in this bulletin. The first type of data collected relates to the demographic or population characteristics of Louisiana and the Louisiana coastal area; the second class of data was obtained to provide an overview of the natural resource base of the coastal area and of selected industries and employment characteristics of this area; the third class of data was collected with the idea in mind of providing a picture of the recreation activities and potentials of this part of the state.

It is hoped that the findings reported will be useful to local planners and to representatives of state and federal agencies seeking to formulate plans for the long range, orderly conservation and development of Louisiana's coastal area.

The Louisiana Coastal Zone: A Definition

The Louisiana coastal zone, by any definition, is a unique area of variety and constant change. It is also characterized by prolific biological production. However, it has an indistinct physical character which makes it difficult to delineate a precise boundary between coastal and noncoastal regions. The definitions of the coastal zone which have been attempted have tended to vary with the purposes and interpretations of writers and researchers. Generally, the coastal zone has been defined as an area with transitional rather than specific boundaries.[2]

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[1] The second phase, which is underway and will be reported later, is a study of local influentials. It is designed to determine the knowledge and attitudes of local persons toward coastal zone management and wetland resource development. The third phase of the overall study will be undertaken later. It will be devoted to a determination of the level of knowledge and attitudes of a statewide sample of citizens.

A transitional boundary could not be accepted for this study for two major reasons. First, data of the type sought are normally reported on a parish (county) basis; second, decisions related to coastal zone management are implemented ultimately within the framework of local political units. It was for these reasons that an independent delineation of the Louisiana coastal zone was made and used.

In working out a delineation of the coastal zone of Louisiana, the first step was to determine what physical features could be used as acceptable indicators of such an area. It was discovered, after a review of literature, that there was widespread concensus on the interpretation that the coastal zone is "a region of transition between the land and sea, encompassing a wide heterogeneity of physical features and a broad array of activities. . . . "[3] The notion that the coastal zone includes the land and salt water interface was also universally accepted.

On the basis of the above criteria it was clear that the land adjacent to the high water marks of the sea must be included as part of coastal regions. It was also apparent that the areas of "marine influence," which include river basins and watersheds, were an integral part of these regions.[4] With these considerations in mind the Louisiana coastal zone was defined in terms of areal contiguity to the coast and its primary drainage channels.

Study of a map of Louisiana showing the details of waterways will reveal that the bayous Nezpique and des Cannes extend north from the Gulf of Mexico into Evangeline Parish and that Pointe Coupee Parish is the northern limit reached by the Atchafalaya River, which also empties into the Gulf. It will also indicate that East Baton Rouge Parish includes a port of major status, connected to the Gulf of Mexico via the Mississippi River, and that the Tangipahoa River extends into Tangipahoa Parish linking that parish with the Gulf. These were the major waterways used to delineate the coastal zone decided upon. Altogether, 29 parishes were included in the final delineation (see Figure 1). The coastal zone delineated (adjusted to parish boundaries) corresponds closely to the physiographic regions labeled marginal plain, marginal basin, deltaic plain, and alluvial valley by Frazier and Osanik.[5]

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[2] Justin Rutka and Chennat Gopalakrishnan, *Spheres of Influence in Hawaii's Coastal Zone,* Vol. 1, Federal Agency Involvement. Sea Grant Advisory Report, UNIHI-Sea Grant-AR-72-03, March, 1973, p. 6.

[3] *Ibid.*

[4] This perspective of shore plus zone of direct influence impinging on the coastal waters conforms, for example, to the definition of coastal zone which appears in the Federal Coastal Zone Management Act of 1972.

[5] After Frazier and Osanik, 1968 as reproduced in *Louisiana Government and the Coastal Zone*—1972, Louisiana Advisory Commission on Coastal and Marine Resources, March 31, 1972.

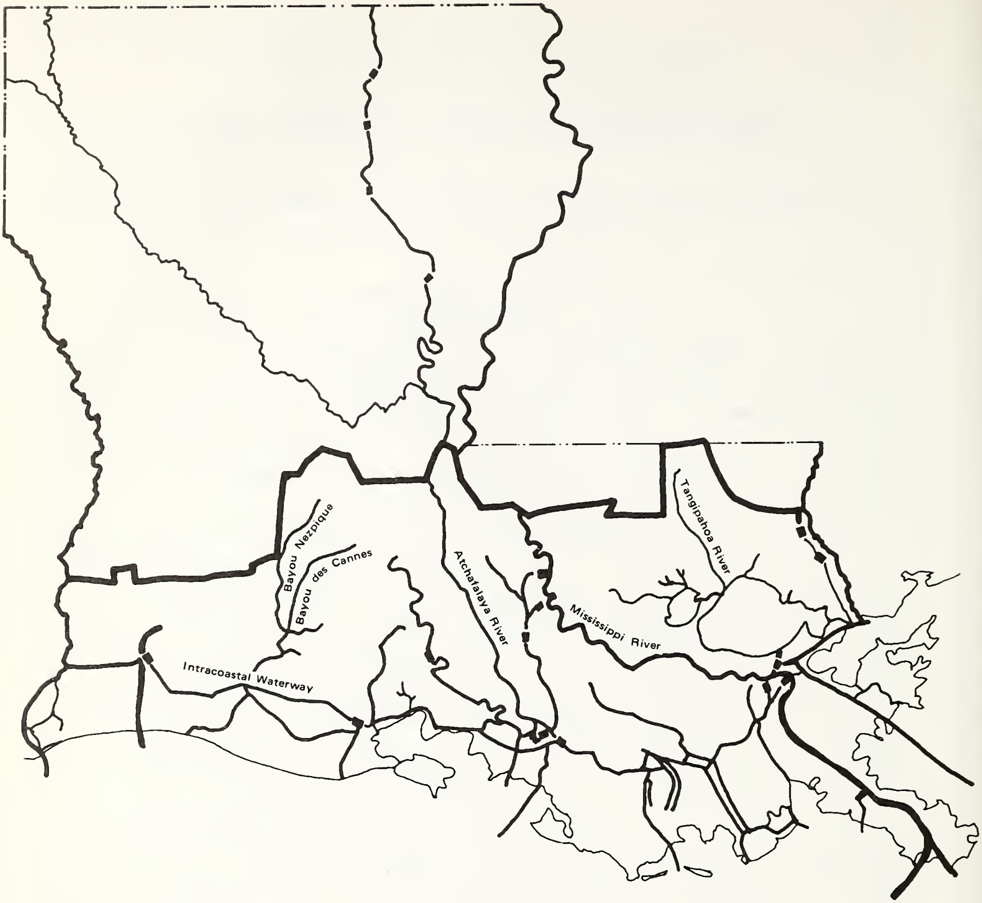

Figure 1.—Coastal zone of Louisiana showing primary drainage channels.

In contemplating the above delineation, the reader should be aware that there is some divergence from the region delineated by Jones and Rice in another recent Sea Grant supported study.[6] This difference is in the inclusion of an additional five parishes (to the north of the Jones and Rice coastal region border) in the present delineation. The data in this report are given by parish so that comparisons between the two studies can be made. Anyone wishing to rearrange the data in terms of the Jones and Rice study can do so by subtracting the appropriate data for the extra five parishes from the totals for the coastal zone.[7]

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[6] Lamar Jones and G. Randolph Rice, *An Economic Base Study of Coastal Louisiana,* Center for Wetland Resources, Louisiana State University, Baton Rouge, LSU-SG-72-02.

Demographic Profile of the Louisiana Coastal Zone

It was pointed out in the introduction that the major objective of this research was to determine the demographic and socio-cultural characteristics of the people in the coastal and noncoastal areas of Louisiana. The demographic material presented in this section is in keeping with this objective. It was selected to highlight population characteristics which would be meaningful in explaining coastal-noncoastal differences in behavioral patterns. The following discussion emphasizes the overall differences between the coastal and noncoastal areas. However, because of the need for making comparisons and because the interest of individuals and planning agencies tends to be in individual parishes, a relatively large number of tables are included which show statistical information by parish.

Size and Density of Population

The 29 parishes of the Louisiana coastal zone include less than half (42 percent) of the state's land area but over two-thirds (67 percent) of its people. Coastal Louisiana has a population density of 133 persons per square mile, as compared with a density of 45 persons per square mile in noncoastal Louisiana (Table 1). This fact contradicts the popular conception of coastal Louisiana as an area of marshes and swamps and relative isolation. It is a factor which has an important bearing on the types of problems which have accrued or will accrue in coastal areas.

Altogether, almost 2.5 million people live in the coastal parishes of Louisiana. The largest population concentration is in the southeastern part of the state and is accounted for by the New Orleans metropolitan development (see Figure 2). The noncoastal parishes include about 1.2 million persons, which is less than half of the people in the coastal region. Again, it is worth noting that planning for coastal Louisiana means planning for the majority of Louisianians.

Residence Characteristics

Louisiana, in keeping with trends prevalent throughout the United States, is becoming more urban each year. The population classified as urban within the state increased from 63 percent in 1960 to 66 percent in 1970 (Table 1). For the purposes of this report, it is significant that the urbanization trend is especially strong in the coastal zone. It may come as a surprise to many that in 1970 almost three out of every four persons

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[7] For another example of a choice of parishes for the coastal zone, see *Louisiana Wetlands Prospectus*, Louisiana Advisory Commission on Coastal and Marine Resources, September 1973, pp. 1-8.

TABLE 1.--Land Area, Population Size, and Urban-Rural Components for Louisiana, the Coastal Zone, and the Noncoastal Area for 1970 and 1960

	Land Area		Total Population			Urban		Rural		Percent Change, 1960 to 1970		
Region	Square Miles	% of Total	Number	Per Sq. Mi.	% of Pop.	Number	% of Total	Number	% of Total	Total	Urban	Rural
			- - - - - - - - - - - - - 1970 Population - - - - - - - - - - - -									
State	44,930	100.0	3,641,306	81.0	100.0	2,406,150	66.0	1,235,156	34.0	11.8	16.8	3.2
Coastal	19,156	42.6	2,453,982	132.7	67.0	1,780,795	72.6	673,187	27.4	15.0	17.4	9.4
Noncoastal	25,774	57.4	1,187,324	44.9	33.0	625,355	52.7	561,969	47.3	5.5	14.9	-3.3
			- - - - - - - - - - - - - 1960 Population - - - - - - - - - - - -									
State			3,257,022	72.5	100.0	2,060,606	63.0	1,196,416	37.0			
Coastal			2,131,763	111.3	65.0	1,516,771	71.1	615,064	28.9			
Noncoastal			1,125,259	43.7	35.0	543,835	48.3	581,352	51.7			

Source: Table 9, U.S. Bureau of the Census, Census of Population: 1970, Number of Inhabitants, Final Report PC(1)-A20, Louisiana.

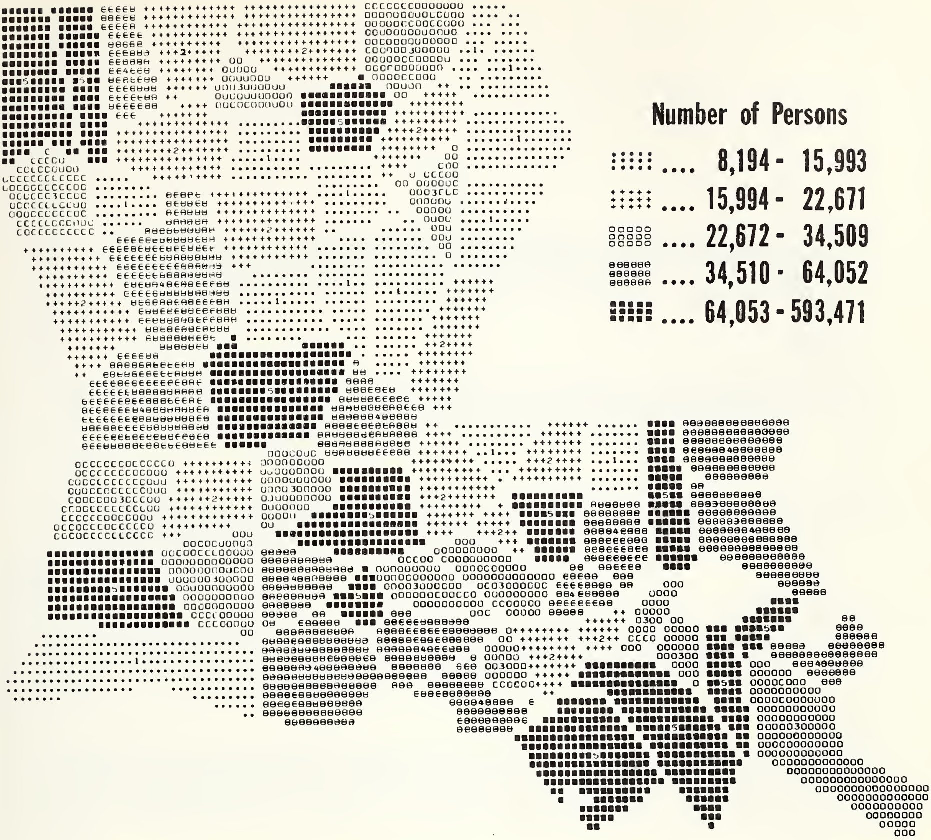

Figure 2.—Population by parish, 1970.

living in this part of the state were classified as urban residents. By contrast, only about half of the inhabitants of the noncoastal region were so classified. This is indeed an important variable, one which sets the coastal parishes apart from the remainder of the state.

By way of explanation, the number of urban people in the coastal area of the state reflects the location there of most of the state's major population centers—New Orleans, Baton Rouge, Lake Charles and Lafayette. The noncoastal region of the state includes only two—Shreveport and Monroe—of the state's six metropolitan areas. The 1970 population of individual parishes in coastal and noncoastal regions is shown in Table 2.

TABLE 2. - Population Size by Race and Sex for the Coastal and Noncoastal Areas of Louisiana, 1970

	1970 Population						
	All Races			White		Negro	
Coastal	Total	Male	Female	Male	Female	Male	Female
Acadia	52,109	25,183	26,926	20,288	21,429	4,885	5,476
Ascension	37,086	18,315	18,771	13,532	13,516	4,749	5,208
Assumption	19,654	9,693	9,961	6,166	6,132	3,518	3,818
Calcasieu	145,415	70,958	74,457	55,775	57,915	15,072	16,396
Cameron	8,194	4,120	4,074	3,818	3,809	286	256
East Baton Rouge	285,167	138,216	146,951	99,313	103,215	38,407	43,374
Evangeline	31,932	15,583	16,349	11,476	11,771	4,081	4,543
Iberia	57,397	27,873	29,524	20,285	21,059	7,553	8,411
Iberville	30,746	14,874	15,872	7,959	8,143	6,873	7,704
Jefferson	337,568	165,499	172,069	144,530	149,950	20,427	21,523
Jefferson Davis	29,554	14,307	15,247	11,414	12,073	2,877	3,148
Lafayette	109,716	53,333	56,383	41,829	43,811	11,395	12,462
Lafourche	68,941	34,147	34,794	30,369	30,677	3,706	4,025
Livingston	36,511	18,169	18,342	16,153	16,222	2,008	2,110
Orleans	593,471	275,969	317,502	151,134	172,286	123,401	143,907
Plaquemines	25,225	12,894	12,331	9,729	9,123	2,862	2,916
Pointe Coupee	22,002	10,762	11,240	5,394	5,531	5,362	5,701
St. Bernard	51,185	25,245	25,940	23,853	24,504	1,278	1,353
St. Charles	29,550	14,795	14,755	11,003	10,734	3,772	4,002
St. James	19,550	9,626	10,107	5,157	5,244	4,465	4,856
St. John the Baptist	23,813	11,717	12,096	6,302	6,436	5,397	5,638
St. Landry	80,364	38,833	41,531	22,876	24,183	15,916	17,286
St. Martin	32,453	15,857	16,596	10,358	10,740	5,472	5,820
St. Mary	60,752	29,996	30,756	21,645	21,742	8,189	8,867
St. Tammany	63,585	31,299	32,286	25,496	25,986	5,703	6,184
Tangipahoa	65,875	32,172	33,703	22,266	22,827	9,833	10,815
Terrebonne	76,049	37,822	38,227	31,027	31,224	5,548	5,875
Vermilion	43,071	20,931	22,140	18,136	19,070	2,780	3,050
West Baton Rouge	16,864	8,101	8,763	4,711	4,884	3,387	3,873
Total	2,453,982	1,186,289	1,267,693	851,994	894,236	329,202	368,597

(continued)

TABLE 2. - (continued)

Noncoastal	1970 Population						
	All Races			White		Black	
	Total	Male	Female	Male	Female	Male	Female
Allen	20,794	10,194	10,600	7,764	7,885	2,341	2,628
Avoyelles	37,751	18,329	19,422	13,335	13,951	4,963	5,438
Beauregard	22,888	11,468	11,420	9,262	9,303	2,181	2,082
Bienville	16,024	7,728	8,296	4,094	4,410	3,634	3,882
Bossier	64,519	31,380	33,139	25,201	26,283	6,053	6,659
Caddo	230,184	108,103	122,081	68,946	76,377	38,940	45,413
Caldwell	9,354	4,619	4,735	3,522	3,617	1,079	1,098
Catahoula	11,769	5,688	6,081	4,093	4,231	1,592	1,849
Claiborne	17,024	8,049	8,975	4,023	4,478	4,022	4,492
Concordia	22,578	10,873	11,705	6,795	6,977	4,054	4,709
DeSoto	22,764	10,773	11,991	5,012	5,590	5,758	6,397
East Carroll	12,884	6,213	6,671	2,669	2,588	3,513	4,056
East Feliciana	17,657	8,764	8,893	4,044	4,095	4,710	4,794
Franklin	23,946	11,607	12,339	7,496	7,882	4,103	4,450
Grant	13,671	6,600	7,071	5,161	5,385	1,422	1,676
Jackson	15,963	7,698	8,265	5,288	5,548	2,406	2,699
LaSalle	13,295	6,475	6,820	5,789	5,994	672	805
Lincoln	33,800	16,635	17,165	10,324	9,877	6,263	7,256
Madison	15,065	7,136	7,929	2,888	2,973	4,242	4,943
Morehouse	32,463	15,431	17,032	9,030	9,636	6,393	7,389
Natchitoches	35,219	17,010	18,209	10,808	11,172	6,105	6,951
Ouachita	115,387	55,267	60,120	40,651	43,082	14,548	16,943
Rapides	118,078	56,777	61,301	41,128	43,728	15,487	17,395
Red River	9,226	4,364	4,862	2,568	2,769	1,791	2,087
Richland	21,774	10,445	11,329	6,337	6,567	4,098	4,734
Sabine	18,638	9,121	9,517	7,366	7,586	1,749	1,922
St. Helena	9,937	4,789	5,148	2,120	2,271	2,669	2,876
Tensas	9,732	4,601	5,131	1,901	2,048	2,684	3,072
Union	18,447	8,919	9,528	5,931	6,356	2,984	3,166
Vernon	53,794	38,219	15,575	33,528	14,080	4,255	1,324
Washington	41,987	20,070	21,917	13,678	14,749	6,376	7,136
Webster	39,939	19,263	20,676	13,437	13,947	5,816	6,706
West Carroll	13,028	6,327	6,701	5,167	5,375	1,156	1,324
West Feliciana	11,376	8,323	3,053	2,730	997	5,588	2,050
Winn	16,369	7,937	8,432	5,552	5,823	2,382	2,603
Total	1,187,324	585,195	602,129	397,638	397,630	186,029	203,004

Source: Table 35, U.S. Bureau of the Census, Census of Population: 1970, General Population Characteristics, Final Report PC(1)-B20, Louisiana.

Race Characteristics

Racial groups are important sources of variation in any population. It was for this reason that data on the racial composition of the coastal and noncoastal parishes were compiled (Table 2 and Figure 3).

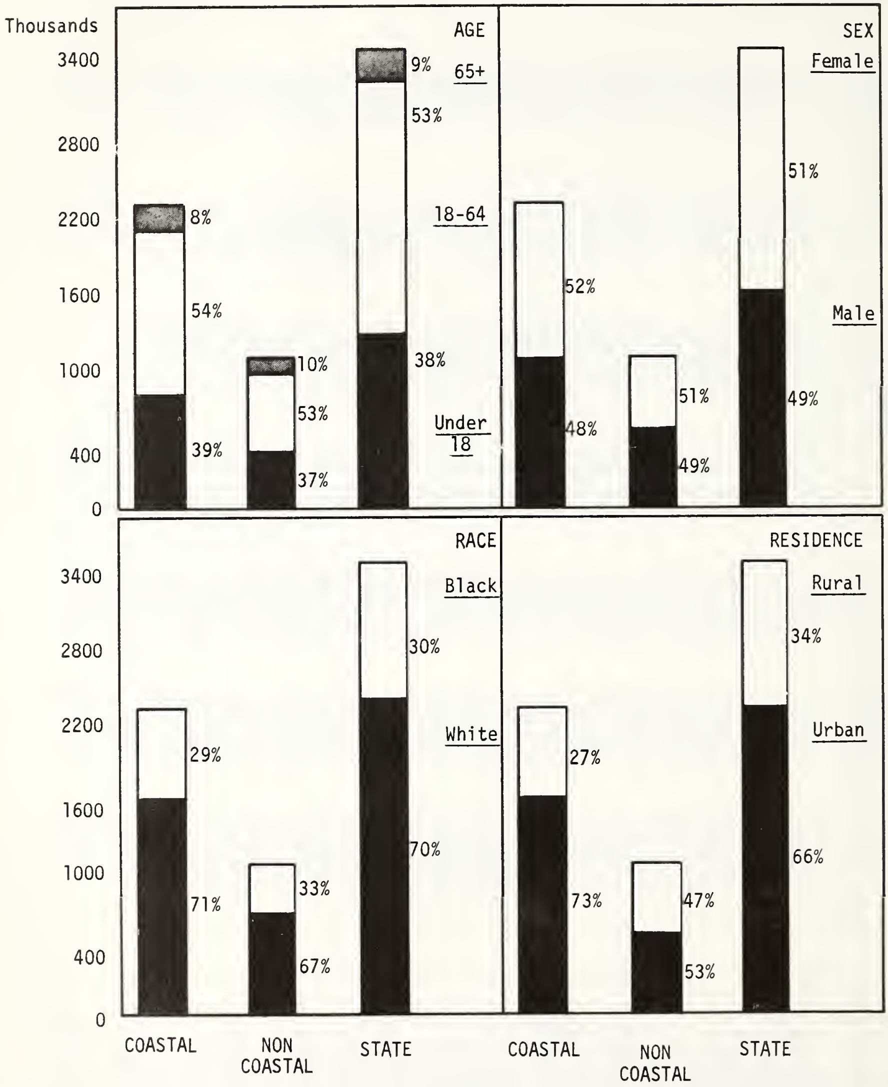

Figure 3.—Selected population characteristics for Louisiana by coastal and noncoastal areas, 1970.

Source: U.S. Bureau of the Census, Census of Population: 1970, General Population Characteristics, Final Report PC(1)-B-20 Louisiana, Table 35.

Persons acquainted with Louisiana will understand why, relatively speaking, more blacks are present in the noncoastal parishes. In certain of the noncoastal parishes of the state one out of every three persons is black, a phenomenon which traces to the patterns of land holding and agriculture prevalent in ante bellum times. The coastal parishes include only 29 percent black in their population, although this too is a larger percentage than in most of the U.S. In terms of absolute numbers, there are considerably more blacks in the coastal zone than in the noncoastal region; in fact, in 1970 there were almost twice as many—697,799 as compared with 389,033.

The significance of the above finding is hard to assess at this time. Cultural practices which tended to distinguish the races in the past are undergoing change, as are the life patterns of members of the black and white communities. Nevertheless, it is logical to assume that some activities and some attitudes relating to the use of coastal areas will vary from one race to another. Local persons will be in a more advantageous position to assess these variances and this is one of the reasons data on race are provided by parish in Table 2.

Age Characteristics

Age is also an important demographic variable. Median ages are lower in the coastal parishes and higher in the north or noncoastal part of the state, as illustrated in Figure 4. It can also be seen in Figure 3 that the coastal parishes have slightly higher percentages of the population under 18 years and lower percentages over 65 years.

The population pyramids in Figure 5 were constructed to show the age (and sex) composition of the coastal and noncoastal populations in another way. The outer pyramids show the age structure of the white population and the inner pyramids represent the blacks in each age and sex category. The shapes of the coastal and noncoastal population pyramids differ in such a way as to indicate the younger population in the coastal parishes.

Variations in the shapes of the population pyramids largely reflect migration patterns and birth rates of previous years. This is clearly the case for blacks in both coastal and noncoastal parishes. There is a dramatic decrease in the number of black males and females near the age of 20. This is the group which accounts for a large share of the migration out of the state, and especially in the noncoastal, rural areas. At the base of each population pyramid it is possible to note a decline in birth rates, which is shown in fewer numbers in the youngest two age categories.

High rates of population growth were also characteristic of the coastal parishes during the last two decades, as can be seen in Figures 6 and 7 and Table 3. The major exception to this pattern is Orleans Parish, which lost residents. This loss was in keeping with trends in other cities. It is associated with what has come to be known as the "flight to the suburbs." However, the New Orleans metropolitan area, as a whole, grew rapidly and more than compensated for the loss experienced in the central city.

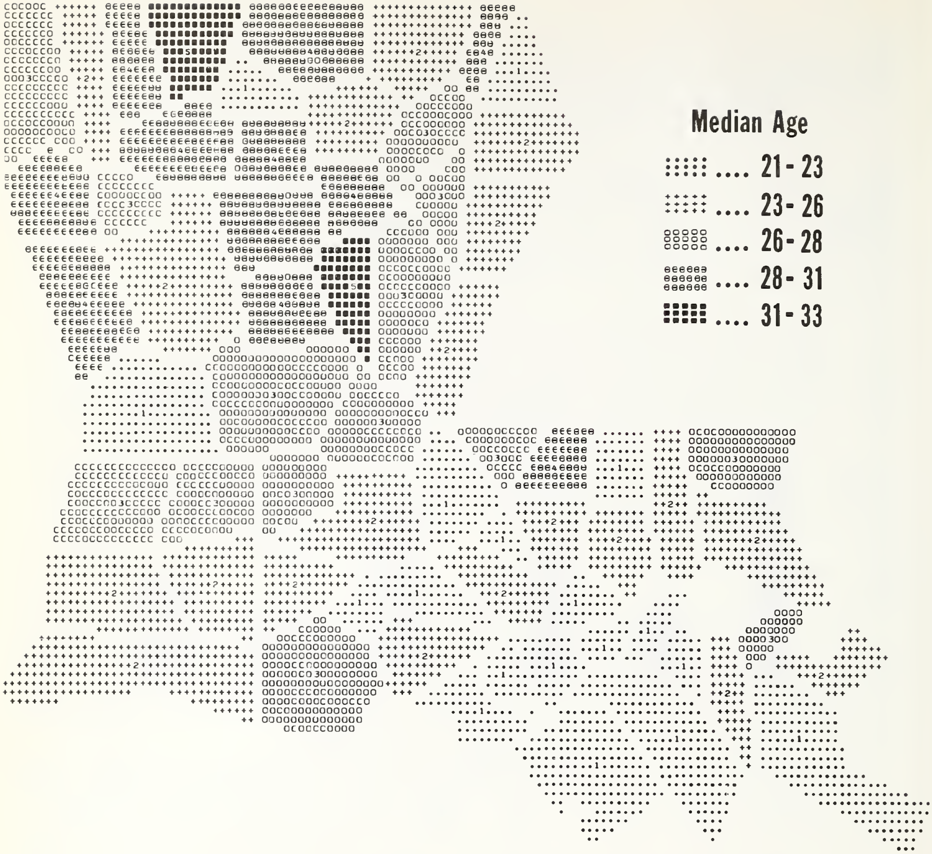

Figure 4.—Median age by parish, 1970.

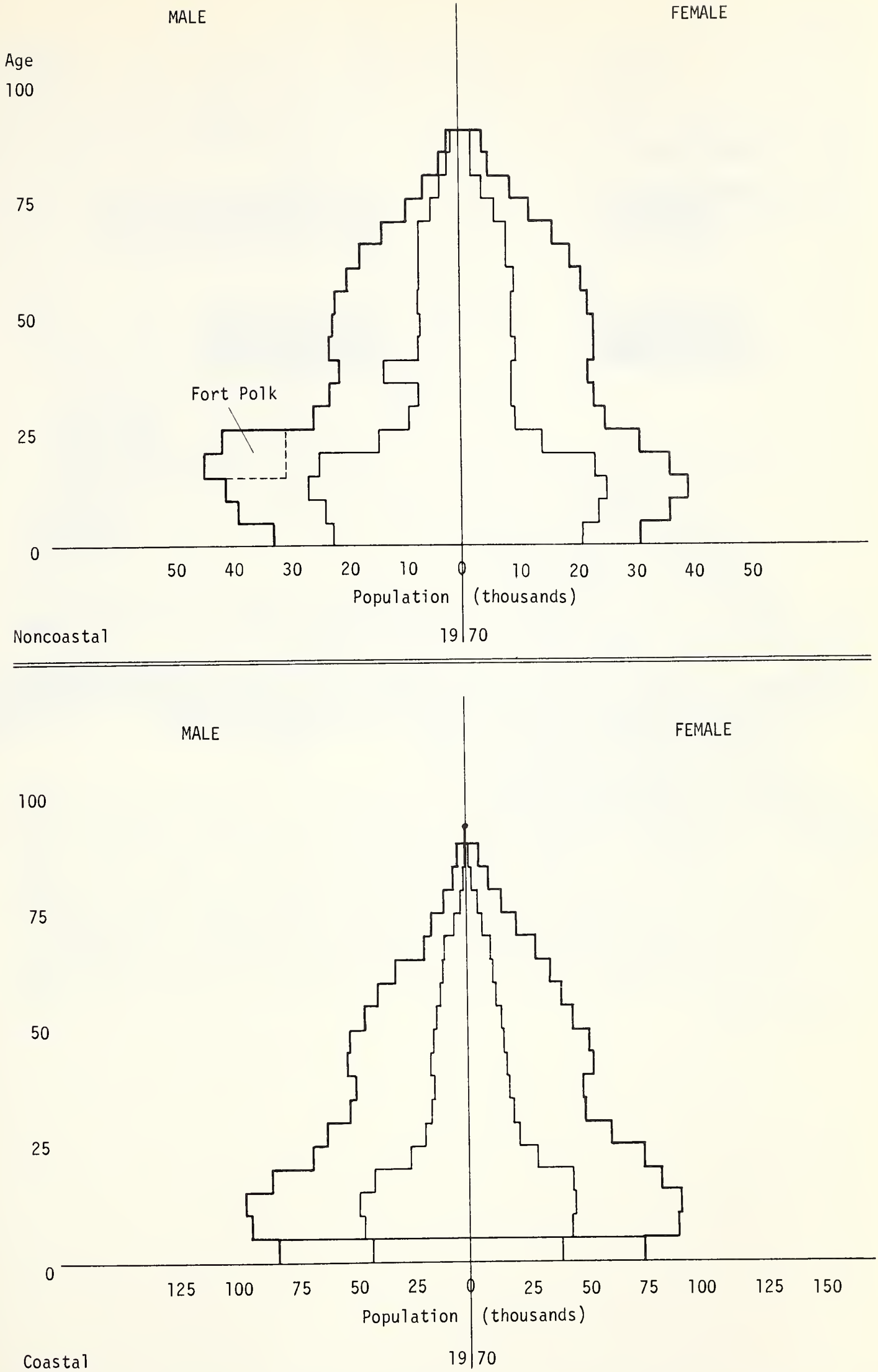

Figure 5.—Population in Louisiana coastal zone and noncoastal area by age, sex, and race, 1970.

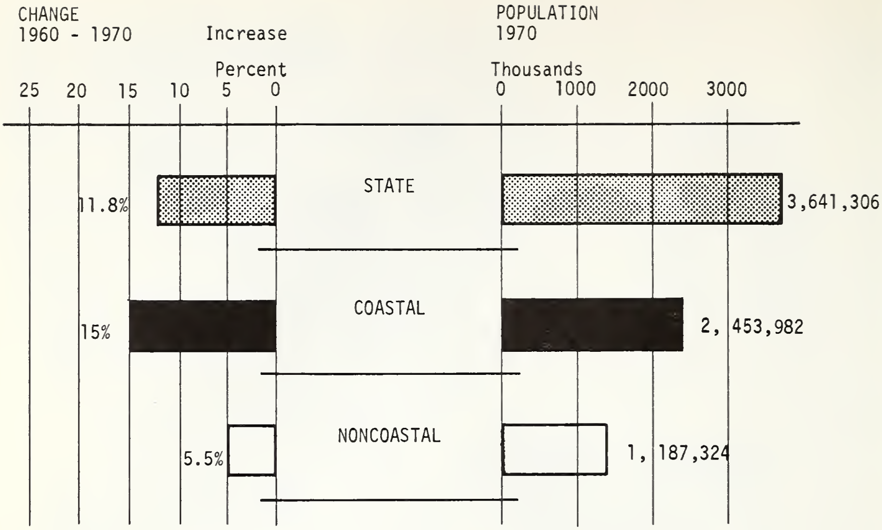

Figure 6.—Louisiana population change, 1960-1970, by coastal and noncoastal areas.

Source: U.S. Bureau of the Census, Census of Population: 1970, Number of Inhabitants, Final Report PC(1)-A-20 Louisiana, Table 9.

In contrast to the coastal parishes, in which population increased by 15 percent between 1960 and 1970, the noncoastal parishes suffered a decrease of 5.5 percent in total population from 1960 to 1970. The only noncoastal parish to experience an unusually large population increase (194 percent between 1960 and 1970) was Vernon. This dramatic growth was due to the reactivation of Fort Polk. Vernon Parish lost population between 1950 and 1960 at a rate (4 percent) similar to other rural, noncoastal parishes.

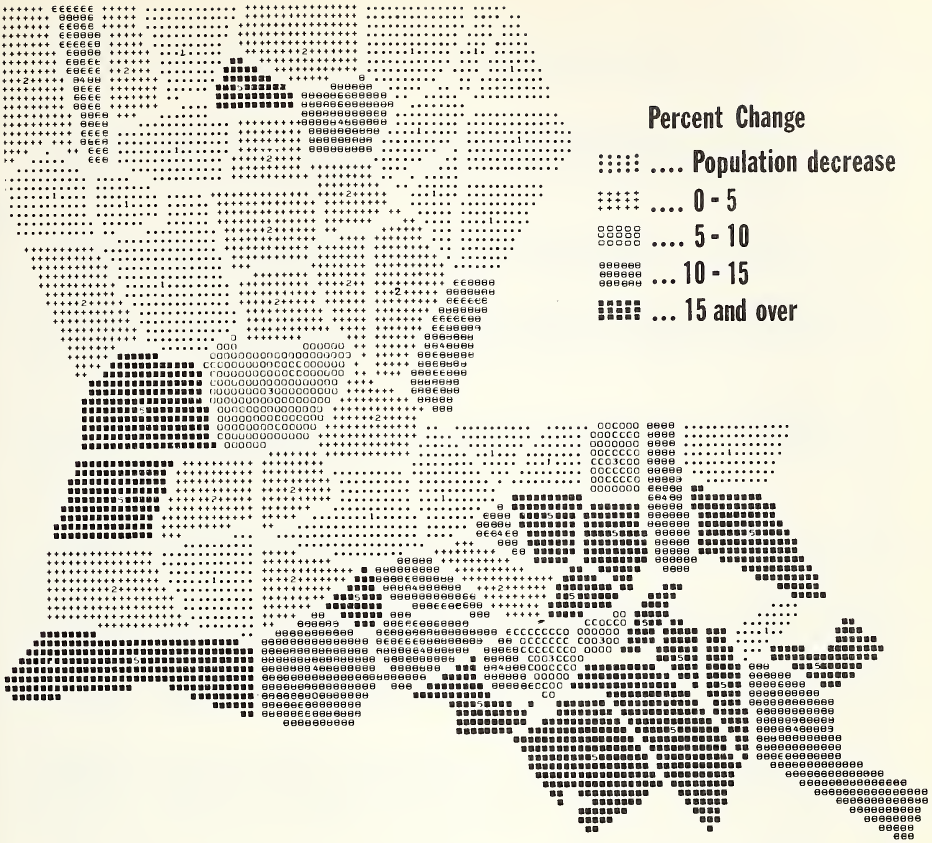

Figure 7—Population change in Louisiana parishes, 1960-1970.

TABLE 3.-Summary of General Characteristics of the Louisiana Population by Parishes, 1970

Parish	Percent Change 60-70	Percent Non-White	Percent Under 18 Yrs.	Percent 18-64 Years	Percent 65 Yrs. and Over	Fertility Ratio	Persons 14 yrs. and Over, % Married		Persons Over 18 Yrs., % Male	Persons Per Household	Median Age	Median Income	Persons 25 Yrs. & Over, Median Yrs. Educ.
							Male	Female					
Coastal													
Acadia	4.4	19.9	40.0	50.8	9.2	458	67.3	61.7	46.8	3.45	25.2	$5,550	8.3
Ascension	32.8	27.1	42.7	50.0	7.3	497	67.5	64.5	48.4	3.67	22.6	7,894	10.3
Assumption	9.2	37.4	43.6	48.2	8.2	541	63.2	60.1	47.7	3.95	21.9	6,135	7.5
Calcasieu	-.0	21.8	39.4	53.9	6.7	384	68.5	64.4	47.5	3.41	24.5	8,404	11.7
Cameron	18.6	6.9	40.3	52.2	7.5	460	70.1	70.9	49.9	3.54	25.1	7,726	9.4
East Baton Rouge	24.0	29.0	36.9	57.0	6.0	347	64.3	59.6	47.1	3.35	23.9	9,627	12.3
Evangeline	0.9	27.2	40.0	50.4	9.6	479	68.8	65.9	47.4	3.33	25.8	4,289	7.6
Iberia	11.1	28.0	42.4	49.9	7.7	477	67.4	62.5	47.0	3.65	23.4	7,109	9.4
Iberville	2.7	47.6	42.1	48.4	9.5	477	61.6	57.0	46.6	3.71	23.2	6,259	8.7
Jefferson	61.7	12.8	39.7	55.4	4.9	402	71.3	67.5	47.8	3.52	24.7	10,235	12.1
Jefferson Davis	-.9	20.5	40.9	50.3	8.7	442	68.3	63.9	47.2	3.43	24.8	6,049	9.2
Lafayette	29.6	21.9	39.6	54.6	5.9	392	64.7	61.0	47.5	3.55	22.8	7,916	11.7
Lafourche	24.5	11.5	41.9	52.2	5.9	486	68.0	66.3	48.7	3.76	22.3	7,855	8.5
Livingston	35.4	11.3	40.6	52.5	7.0	443	70.7	69.9	48.7	3.51	24.0	7,652	10.5
Orleans	-5.4	45.5	34.1	55.3	10.6	349	60.6	53.2	44.6	3.04	27.9	7,445	10.8
Plaquemines	11.9	25.3	42.4	53.4	4.2	476	68.7	69.5	51.7	3.76	22.3	8,601	9.8
Pointe Coupee	-2.2	50.3	42.5	47.4	10.1	473	61.6	58.6	47.5	3.74	23.1	4,957	8.2
St. Bernard	59.0	5.5	40.1	55.5	4.4	362	70.9	67.9	48.2	3.72	24.0	9,638	11.0
St. Charles	39.3	26.4	44.5	49.9	5.6	472	67.6	65.6	48.5	3.88	21.6	9,004	10.9
St. James	7.4	47.3	45.1	46.9	8.0	514	59.4	55.7	46.9	4.24	20.6	8,049	9.6
St. John the Baptist	29.1	46.5	44.7	48.8	6.5	498	63.1	61.0	48.3	4.12	21.2	8,275	9.9
St. Landry	-1.4	41.4	42.3	49.4	8.3	452	64.3	59.6	46.7	3.65	23.3	4,919	7.8
St. Martin	11.7	35.0	43.5	49.1	7.4	500	65.1	62.6	48.1	3.84	22.0	5,157	7.5
St. Mary	24.4	28.6	43.5	50.4	6.1	511	67.9	65.6	48.6	3.75	22.1	8,146	9.9
St. Tammany	64.5	19.0	41.0	51.5	7.5	407	68.1	65.5	48.0	3.51	25.0	8,655	11.9
Tangipahoa	10.8	31.5	38.7	52.4	8.9	414	61.2	57.8	47.3	3.40	23.5	5,208	9.6
Terrebonne	25.1	18.1	44.1	50.8	5.1	495	67.2	66.6	48.8	3.87	21.5	8,338	9.6
Vermilion	10.9	13.6	38.7	51.1	10.2	441	69.4	65.5	47.6	3.35	27.0	5,946	8.3
West Baton Rouge	14.0	43.1	43.4	49.7	6.9	501	65.9	60.3	47.1	3.81	21.9	6,920	10.1

(Continued)

TABLE 3.-(continued)

Parish	Percent Change 60-70	Percent Non-White	Percent Under 18 Yrs.	Percent 18-64 Years	Percent 65 Yrs and Over	Fertility Ratio	Persons 14 Yrs. and Over, % Married Male	Persons 14 Yrs. and Over, % Married Female	Persons Over 18 Yrs., % Male	Persons Per Household	Median Age	Median Income	Persons 25 Yrs. & Over, Median Yrs. Educ.
Noncoastal													
Allen	4.7	24.7	39.8	50.0	10.2	454	66.7	63.8	47.6	3.37	25.9	5,931	9.0
Avoyelles	.4	27.7	39.2	49.3	11.4	455	67.0	62.4	47.0	3.36	27.0	4,435	8.6
Beauregard	19.3	18.9	37.6	52.9	9.4	416	67.2	66.3	48.9	3.29	26.0	6,940	11.1
Bienville	-4.2	46.9	35.6	49.8	14.6	446	66.7	61.7	47.4	3.22	30.1	5,187	9.5
Bossier	12.0	20.2	40.9	53.2	6.0	401	72.1	68.0	46.9	3.43	23.6	7,927	12.1
Caddo	2.8	36.9	36.3	53.4	10.3	365	67.1	58.8	45.0	3.13	27.6	8,103	12.0
Caldwell	3.9	23.7	36.1	50.3	13.6	391	63.7	60.5	47.4	3.20	29.9	5,224	9.7
Catahoula	3.0	29.3	40.5	49.0	10.5	406	65.7	61.0	47.3	3.45	25.7	4,850	9.3
Claiborne	-12.3	50.1	34.6	48.3	17.1	430	67.0	59.0	45.4	3.07	33.3	5,347	9.3
Concordia	10.3	39.0	42.5	49.5	8.0	441	65.6	61.4	46.7	3.60	23.3	6,321	9.9
DeSoto	-6.1	53.4	36.9	48.4	14.7	426	64.6	56.4	45.4	3.19	29.2	5,074	8.9
East Carroll	-10.7	59.2	45.1	44.0	10.9	583	58.8	53.2	44.8	3.70	21.4	3,612	8.1
East Feliciana	-12.6	53.9	35.0	51.6	13.4	396	50.8	50.8	49.1	3.77	30.4	5,755	8.4
Franklin	-8.2	35.8	40.5	48.1	11.4	461	65.4	60.7	46.4	3.45	25.7	4,171	8.9
Grant	2.6	22.9	36.4	50.5	13.2	402	67.7	63.1	46.5	3.19	30.1	5,329	9.6
Jackson	.9	32.1	33.9	53.7	12.3	382	69.1	63.2	46.8	3.08	30.6	6,608	10.0
LaSalle	2.2	11.4	34.4	52.9	12.6	388	71.0	66.1	47.5	3.08	31.0	5,799	10.2
Lincoln	18.5	40.2	28.6	62.0	9.3	258	51.4	50.3	48.5	3.07	22.9	6,535	12.0
Madison	-8.4	61.1	42.9	44.4	12.8	560	61.6	54.3	44.8	3.44	23.5	3,981	8.5
Morehouse	-3.7	42.5	40.6	48.5	10.9	454	66.0	58.6	45.4	3.39	25.4	5,708	9.5
Natchitoches	-1.2	37.6	34.4	54.3	11.3	338	56.9	53.4	46.9	3.26	23.9	4,598	9.4
Ouachita	13.5	27.4	37.1	54.2	8.7	386	65.8	59.8	45.9	3.24	24.9	7,354	11.7
Rapides	6.0	28.1	37.6	53.2	9.2	383	65.0	60.2	46.8	3.29	25.9	6,831	11.1
Red River	-7.5	42.2	37.8	48.8	13.4	427	65.8	59.4	45.4	3.26	28.0	4,563	9.2
Richland	-8.6	40.7	39.7	48.2	12.1	429	65.1	59.5	45.9	3.47	25.9	4,868	8.9
Sabine	.4	19.8	36.4	50.0	13.6	459	66.6	63.1	47.5	3.22	28.8	5,146	9.3
St. Helena	8.5	55.8	44.5	46.8	8.7	514	62.7	59.4	47.0	3.87	21.3	4,107	9.2
Tensas	-17.5	59.4	42.3	44.7	13.0	473	61.3	54.5	45.1	3.43	24.5	3,173	7.9
Union	4.7	33.4	35.3	51.1	13.6	390	68.0	61.7	46.5	3.23	29.8	5,976	9.7
Vernon	193.9	11.5	22.9	72.9	4.2	435	39.2	72.3	76.0	3.23	21.8	6,450	11.8
Washington	-4.6	32.3	38.2	51.5	10.3	386	67.2	61.3	46.3	3.23	27.2	6,377	10.3
Webster	.6	31.4	34.5	54.1	11.4	352	70.0	64.6	46.6	3.11	29.7	7,215	10.6
West Carroll	-8.1	19.1	37.5	51.0	11.5	398	69.2	63.9	47.4	3.25	28.9	4,802	9.2
West Feliciana	-8.2	67.2	24.1	70.6	5.4	515	41.3	55.7	79.5	3.88	27.2	5,355	9.1
Winn	2.1	30.5	35.2	51.8	13.0	416	67.8	63.4	47.5	3.11	30.1	5,405	9.7

Source: U.S. Bureau of the Census, Census of Population: 1970, General Population Characteristics Final Report PC(1)-B20, La.

TABLE 4.-Births and Deaths in Louisiana for 1970 by Race and Area of the State

Region	Births (By Residence)				Deaths (By Residence)			
		Rate Per	Race			Rate Per	Race	
	Total	1000	White	Black	Total	1000	White	Black
State	74,615	20.5	46,666	27,949	33,386	9.2	21,672	11,714
Coastal	51,010	20.8	32,835	18,179	21,553	8.75	14,405	7,148
Noncoastal	23,605	19.9	13,835	9,770	11,833	10.0	7,303	4,530

Source: Table VII, p. 16 and Table XVII, p. 44, Statistical Report of the Bureau of Vital Statistics, 1970, Louisiana State Department of Health.

When a comparison of birth, death, and migration rates is made between the coastal and noncoastal parishes the following picture emerges. The birth rate is slightly higher in the coastal area, 20.8 per 1,000 persons as compared with 19.9 per 1,000 in the noncoastal area (Table 4). If birth rates are broken down by race, two additional facts become evident. First, blacks have a much higher crude birth rate in both coastal and noncoastal areas. Second, the birth rates of both blacks and whites are higher in the coastal area (Table 5).

When comparisons of the crude death rate are made, it is found that people in the coastal parishes have the lower rate. The death rate there is 8.75 per 1,000 persons annually as compared with 10 per 1,000 persons in the noncoastal area. The crude death rate is higher for blacks in both regions, but is especially noticeable in the northern (noncoastal) parishes.

From the above, it might be deduced that the favorable relation between the birth rate and death rate in the coastal area would make for a higher natural increase. This is true, but it is only a part of the growth picture. Looking at the effect of migration alone, the state as a whole had a net population loss of 3 percent, which was due to relatively large numbers of blacks leaving the state and relatively low in-migration by whites (see Table 6). All but four parishes (Cameron, Jefferson, St. Charles and Vernon) had net migration losses among the nonwhites. These losses were especially high in the noncoastal parishes, 18.5 percent as compared with 7.8 percent in the coastal parishes. The data on white migrants indicate that slightly more whites came into the state than left from 1960 to 1970. The coastal parishes had an advantage in this regard in that they attracted more in-migrants than the noncoastal parishes. The respective rates of increase were 1.6 percent and 1.2 percent.

Two other population growth and composition facts are evident from the shape of the population pyramids in Figure 5. The first is the effect of migration patterns and birth rates of previous years. This is shown dramatically in the case of blacks in both coastal and noncoastal parishes.

TABLE 5.-Crude Birth Rate and Death Rate by Parish, 1970

Parish	Birth Rate	Death Rate
COASTAL		
Acadia	20.2	9.3
Ascension	24.0	8.1
Assumption	20.6	9.4
Calcasieu	21.3	7.7
Cameron	15.6	4.9
East Baton Rouge	21.2	7.0
Evangeline	20.4	10.5
Iberia	23.0	7.9
Iberville	21.5	10.6
Jefferson	20.6	6.2
Jefferson Davis	18.9	9.5
Lafayette	21.7	6.1
Lafourche	19.8	7.3
Livingston	22.3	7.7
Orleans	19.1	12.3
Plaquemines	26.0	7.1
Pointe Coupee	20.5	10.2
St. Bernard	19.7	5.8
St. Charles	21.4	6.1
St. James	22.8	9.1
St. John the Baptist	21.9	7.9
St. Landry	22.8	9.9
St. Martin	20.9	8.4
St. Mary	23.8	8.0
St. Tammany	19.9	8.5
Tangipahoa	21.9	10.4
Terrebonne	23.8	7.4
Vermilion	17.8	9.9
West Baton Rouge	22.1	9.5

(continued)

The drastic decrease in the number of black males and females near the age of 20 indicates this age group accounts for the largest share of the migration out of the state, especially in the noncoastal, rural areas. The second fact discernable from the pyramids is that the birth rate has declined within recent years. At the base of each population pyramid it is possible to note the fewer numbers in the youngest two age categories. This is meaningful in terms of planning for the future.

TABLE 5.-(continued)

Parish	Birth Rate	Death Rate
NONCOASTAL		
Allen	21.0	10.9
Avoyelles	19.3	9.9
Beauregard	20.1	10.7
Bienville	18.4	12.0
Bossier	25.3	6.8
Caddo	21.2	10.0
Caldwell	16.6	11.4
Catahoula	17.7	9.0
Claiborne	17.7	12.2
Concordia	19.1	9.4
DeSoto	18.2	12.8
East Carroll	24.2	12.0
East Feliciana	19.5	10.3
Evangeline	20.4	10.5
Franklin	18.1	9.6
Grant	18.6	12.1
Jackson	17.9	11.3
LaSalle	18.4	12.0
Lincoln	16.8	8.6
Madison	26.1	13.3
Morehouse	21.6	10.0
Natchitoches	19.7	10.4
Ouachita	22.1	9.2
Rapides	20.2	10.0
Red River	19.3	10.0
Richland	22.5	12.4
Sabine	19.0	11.8
St. Helena	15.8	8.5
Tensas	19.2	12.7
Union	15.8	11.5
Vernon	10.9	5.7
Washington	19.5	12.0
Webster	18.6	10.2
West Carroll	20.0	10.0
West Feliciana	12.8	6.2
Winn	18.7	13.0

Source: Table V and Table XVIII, Statistical Report of the Bureau of Vital Statistics, 1970, Louisiana State Department of Health.

TABLE 6.-Net Migration for Whites and Nonwhites by Parish, 1960-1970

Parish	Expected 1970 Population*		1970 Census Population		Net Migration			
					Number		Percent*	
	Whites	Nonwhites	Whites	Nonwhites	Whites	Nonwhites	Whites	Nonwhites
Coastal								
Acadia	45,806	12,335	41,717	10,392	-4,089	-1,943	-8.9	-15.8
Ascension	22,770	10,611	27,048	10,038	4,278	-573	18.8	-5.4
Assumption	12,280	8,889	12,298	7,356	18	-1,533	0.1	-17.2
Calcasieu	132,506	36,921	113,690	31,725	-18,816	-5,196	-14.2	-14.1
Cameron	7,466	541	7,627	567	161	26	2.2	4.8
East Baton Rouge	184,198	86,645	202,528	82,639	18,330	-4,006	10.0	-4.6
Evangeline	24,948	10,943	23,247	8,685	-1,701	-2,258	-6.8	-20.6
Iberia	44,052	18,564	41,344	16,053	-2,708	-2,511	-6.1	-13.5
Iberville	17,352	17,195	16,102	14,644	-1,250	-2,551	-7.2	-14.8
Jefferson	217,051	40,550	295,071	43,158	78,020	2,608	35.9	6.4
Jefferson Davis	26,668	7,555	23,487	6,067	-3,181	-1,488	-11.9	-19.7
Lafayette	77,402	26,014	87,217	24,528	9,815	-1,486	12.7	-5.7
Lafourche	59,274	8,841	61,046	7,895	1,772	-946	3.0	-10.7
Livingston	26,688	5,232	32,375	4,136	5,687	-1,096	21.3	-20.9
Orleans	413,988	279,663	323,420	270,051	-90,568	-9,612	-21.9	-3.4
Plaquemines	19,569	8,032	18,852	6,373	-717	-1,659	-3.7	-20.7
Pointe Coupee	11,485	14,089	10,925	11,077	-560	-3,012	-4.9	-21.4
St. Bernard	35,808	2,981	48,357	2,828	12,549	-153	35.0	-5.1
St. Charles	18,947	7,130	21,737	7,813	2,790	683	14.7	9.6
St. James	10,985	11,040	10,401	9,332	-584	-1,708	-5.3	-15.5
St. John the Baptist	10,536	11,677	12,738	11,075	2,202	-602	20.9	-5.2
St. Landry	52,546	42,478	47,059	33,305	-5,487	-9,173	-10.4	-21.6
St. Martin	21,335	13,226	21,098	11,355	-237	-1,871	-1.1	-14.1
St. Mary	41,767	18,177	43,387	17,365	1,620	-812	3.9	-4.5
St. Tammany	32,718	12,789	51,482	12,103	18,764	-686	57.4	-5.4
Tangipahoa	43,717	24,919	45,093	20,782	1,376	-4,137	3.1	-16.6
Terrebonne	61,033	15,856	62,251	13,798	1,218	-2,058	2.0	-13.0
Vermilion	38,280	6,287	37,206	5,865	-1,074	-422	-2.8	-6.7
West Baton Rouge	9,034	8,762	9,595	7,269	561	-1,493	6.2	-17.0
Coastal Total	1,720,209	767,942	1,748,398	708,274	28,189	-59,668	1.6	-7.8

(continued)

TABLE 6.-(continued)

Parish	Expected 1970 Population*		1970 Census Population		Net Migration			
					Number		Percent*	
	Whites	Nonwhites	Whites	Nonwhites	Whites	Nonwhites	Whites	Nonwhites
Noncoastal								
Allen	16,806	5,717	15,649	5,145	-1,157	-572	-6.9	-10.0
Avoyelles	29,158	12,722	27,286	10,465	-1,872	-2,257	-6.4	-17.7
Beauregard	16,584	5,010	18,565	4,323	1,981	-687	11.9	-13.7
Bienville	8,446	9,516	8,504	7,520	58	-1,996	0.7	-21.0
Bossier	51,580	16,826	50,828	12,875	-752	-3,951	-1.5	-23.5
Caddo	156,387	96,558	145,323	84,861	-11,064	-11,697	-7.1	-12.1
Caldwell	6,844	2,816	7,139	2,215	295	-601	4.3	-21.3
Catahoula	8,099	4,675	8,324	3,445	225	-1,230	2.8	-26.3
Claiborne	9,499	10,975	8,501	8,523	-998	-2,452	-10.5	-22.3
Concordia	12,682	10,586	13,772	8,806	1,090	-1,780	8.6	-16.8
DeSoto	10,538	15,939	10,602	12,162	64	-3,777	0.6	-23.7
East Carroll	6,370	10,289	5,257	7,627	-1,113	-2,662	-17.5	-25.9
East Feliciana	9,604	12,660	8,139	9,518	-1,465	-3,142	-15.3	-24.8
Franklin	16,570	12,669	15,378	8,568	-1,192	-4,101	-7.2	-32.4
Grant	10,736	3,786	10,546	3,125	-190	-661	-1.8	-17.5
Jackson	11,320	6,113	10,836	5,127	-484	-986	-4.3	-16.1
LaSalle	12,234	1,901	11,783	1,512	-451	-389	-3.7	-20.5
Lincoln	17,902	13,727	20,201	13,599	2,299	-128	12.8	-0.9
Madison	6,332	12,134	5,861	9,204	-471	-2,930	-7.4	-24.1
Morehouse	19,770	18,960	18,666	13,797	-1,104	-5,163	-5.6	-27.2
Natchitoches	21,640	17,519	21,980	13,239	340	-4,280	1.6	-24.4
Ouachita	78,926	39,571	83,733	31,654	4,807	-7,917	6.1	-20.0
Rapides	86,477	39,099	84,856	33,222	-1,621	-5,877	-1.9	-15.0
Red River	5,452	5,499	5,337	3,889	-115	-1,610	-2.1	-29.3
Richland	14,340	13,040	12,904	8,870	-1,436	-4,170	-10.0	-32.0
Sabine	15,353	5,111	14,952	3,686	-401	-1,425	-2.6	-27.9
St. Helena	4,203	6,190	4,391	5,546	188	-644	4.5	-10.4
Tensas	4,421	8,535	3,949	5,783	-472	-2,752	-10.7	-32.2
Union	11,467	7,687	12,287	6,160	820	-1,527	7.2	-19.9
Vernon	18,291	2,907	47,608	6,186	29,317	3,279	160.3	112.8
Washington	31,370	17,285	28,427	13,560	-2,943	-3,725	-9.4	-21.6
Webster	28,030	15,872	27,384	12,555	-646	-3,317	-2.3	-20.9
West Carroll	11,920	3,877	10,542	2,486	-1,378	-1,391	-11.6	-35.9
West Feliciana	4,472	9,092	3,727	7,649	-745	-1,443	-16.7	-15.9
Winn	11,409	5,724	11,375	4,994	-34	-730	-0.3	-12.8
Noncoastal Total	785,232	480,587	794,612	391,896	9,380	-88,691	1.2	-18.5
Louisiana Total	2,505,441	1,248,529	2,543,010	1,100,170	37,569	-148,359	1.5	-11.9

*1960 population plus natural increase from 1960 to 1970.

Source: 1971 Statistical Report of the Bureau of Vital Statistics, Louisiana State Department of Health, New Orleans, p. 8.

Planners are faced with the necessity of looking ahead as they work out programs of various types. With this thought in mind, population projections for the coastal and noncoastal parishes to 1985 are presented in Table 7 and Figure 8. A study of this data shows the population of the coastal region is expected to increase by another half-million in the 15

TABLE 7.-Projected Population for Louisiana, The Coastal Zone, and Noncoastal Area for 1985

Parish	1970 Population	1985 Population
Coastal		
Acadia	52,109	47,142
Ascension	37,086	50,950
Assumption	19,654	20,934
Calcasieu	145,415	179,563
Cameron	8,194	8,518
East Baton Rouge	285,167	373,567
Evangeline	31,932	28,031
Iberia	57,397	58,520
Iberville	30,746	28,432
Jefferson	337,568	526,291
Jefferson Davis	29,554	24,902
Lafayette	109,716	149,474
Lafourche	68,941	79,175
Livingston	36,511	53,353
Orleans	593,471	587,649
Plaquemines	25,225	28,424
Pointe Coupee	22,002	19,157
St. Bernard	51,185	101,947
St. Charles	29,550	43,907
St. James	19,733	19,262
St. John the Baptist	23,813	32,985
St. Landry	80,364	70,768
St. Martin	32,453	32,776
St. Mary	60,752	75,184
St. Tammany	63,585	140,812
Tangipahoa	65,875	69,608
Terrebonne	76,049	91,361
Vermilion	43,071	41,920
West Baton Rouge	16,864	19,405
Coastal Total	2,453,982	3,004,017
Noncoastal Total	1,187,684	1,142,310
State Total	3,641,666	4,146,327

Source: Roger L. Burford and Sylvia G. Murzyn, Population Projections by Age, Race, and Sex, for Louisiana and Its Parishes, 1970-1985, Number 10, June, 1972.

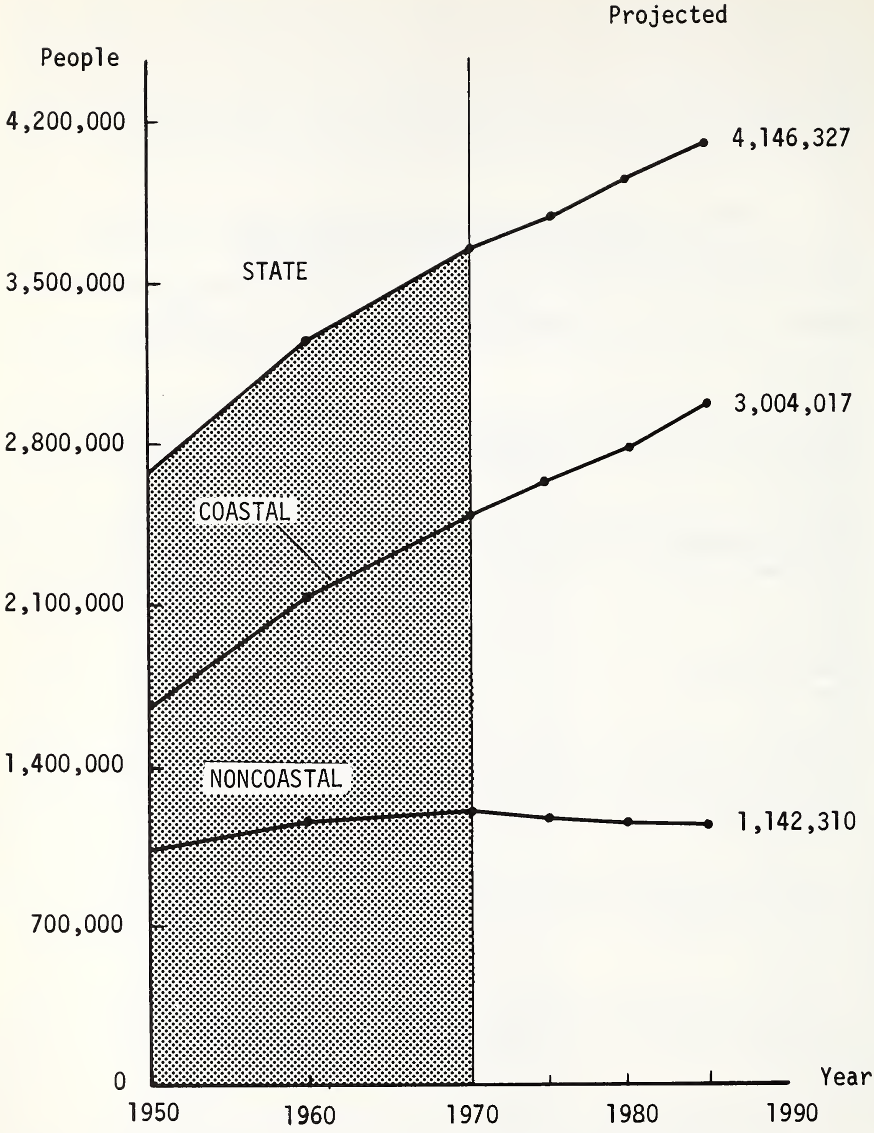

Figure 8.—Population trends for Louisiana, the coastal zone, and noncoastal area, from 1950 to 1985.

Source: Population Projections by Age, Race and Sex for Louisiana and Its Parishes, 1970-1985. Roger L. Burford and Sylvia G. Murzyn.

years following 1970. This is a much different picture than that projected for the noncoastal part of the state, where at best the population is expected to remain at present levels. It indicates that in the coastal region there will be six people in 1985 where there were only five in 1970.

Cultural Characteristics

The population growth of a region is accounted for by births, deaths, and migration, but there are always underlying cultural factors which explain in large part the patterns such as those described in the previous section. The coastal-noncoastal differences in demographic characteristics which were reviewed are explainable to a considerable extent by the cultural contrasts between the two areas. Two rather sharp cultural distinctions are readily detected. First, the coastal region is primarily French in an ethnic sense and contrasts to the noncoastal region, which is primarily inhabited by descendents of Anglo-Saxon, Scotch-Irish, and other non-French European stock. There is a large percentage of blacks in all parts of Louisiana. It is of interest in this context that many blacks in south Louisiana have adopted French cultural traits. The percentage of French-speaking inhabitants in Louisiana, by parish, is shown in Figure 9. In

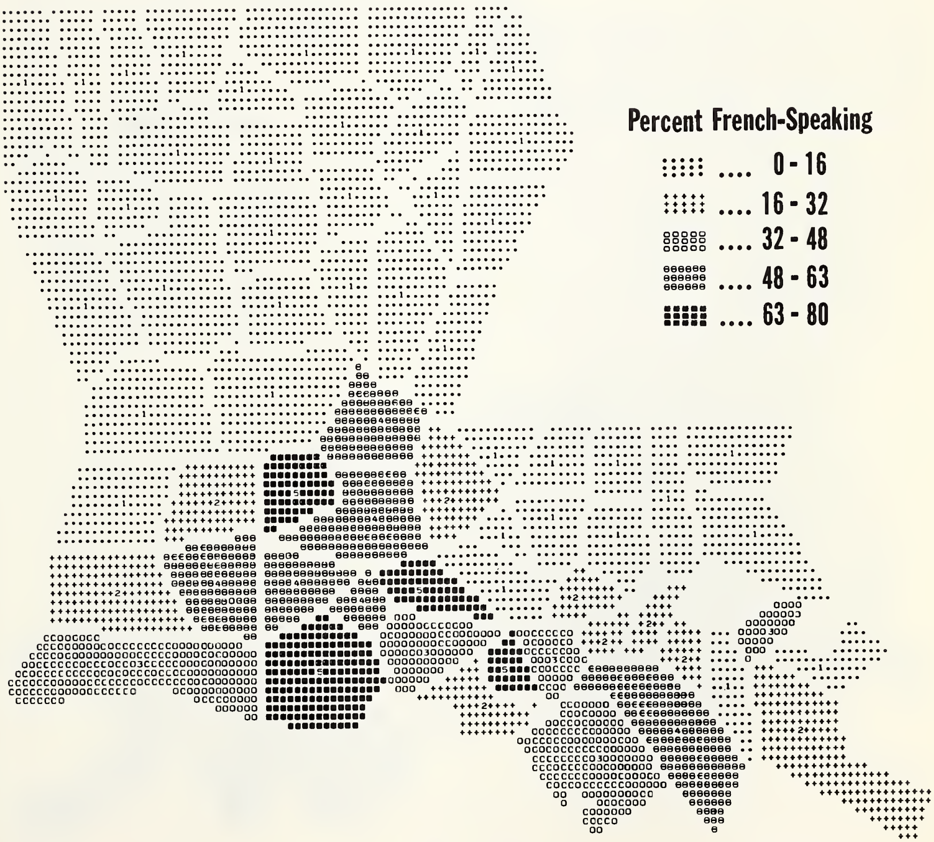

Figure 9.—Percent French-speaking, by parish.

some coastal parishes as many as four out of five persons list French as their mother tongue. There is thus a sharp contrast in cultural tradition, which is accented by the perpetuation of the French language in much of the coastal area.

The second cultural difference which stands out between coastal and noncoastal areas is a function of the first, but stands alone as an explanation of behavioral patterns. This is religion. In the coastal region the Roman Catholic Church predominates, while in the remainder of the state the various Protestant denominations claim the majority of religious communicants. The percent Catholic by parish for 1971 is shown in Figure 10.

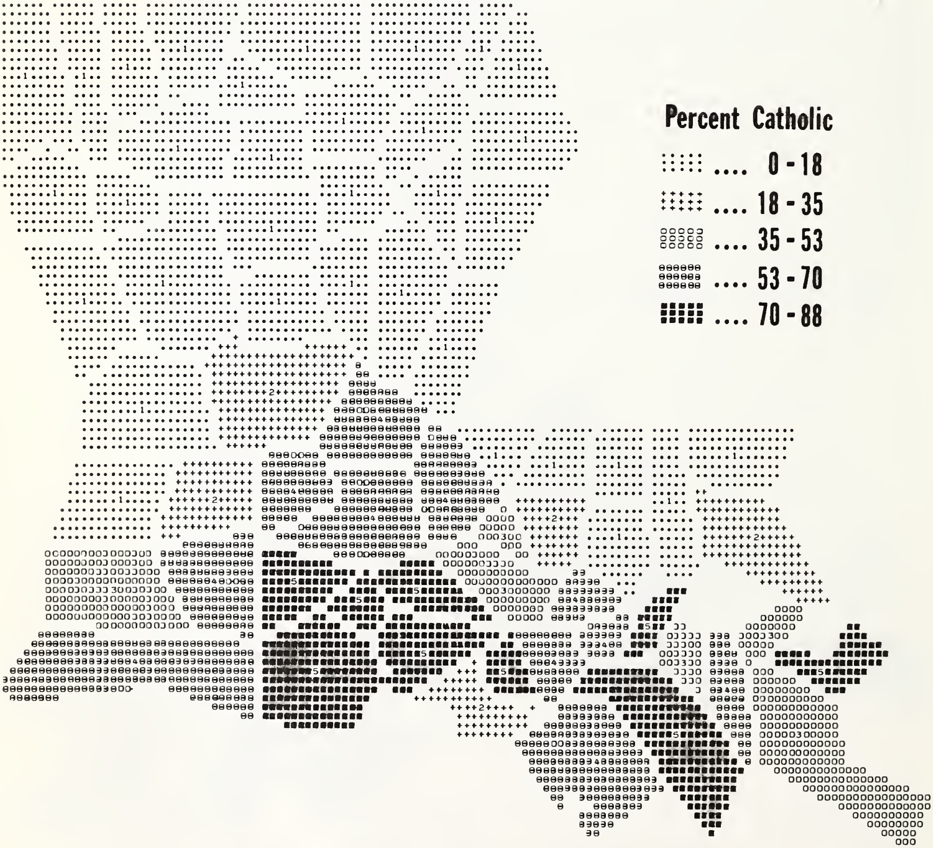

Figure 10.—Percent Catholic, by parish.

There are, of course, differences in the behavioral practices encouraged and/or discouraged by each of these religious groups. One, which has had importance in the recent past, is birth control. The reluctance of Catholics to utilize artificial means of birth control is reflected in a demographic way as follows. A measure of completed family size is the number of children ever born to women between ages 34 and 45. It can be seen in Figure 11 that there is a concentration of parishes with averages of more than four children per woman in the coastal zone. This rate is not subject to fluctuation due to changes in the proportion of women in the population of child-bearing age. It is interesting and in keeping with our point to note that the rate is higher for nonwhites in the noncoastal parishes (4.9) than in the coastal parishes (4.5), while for whites the opposite situation exists (see Table 8).

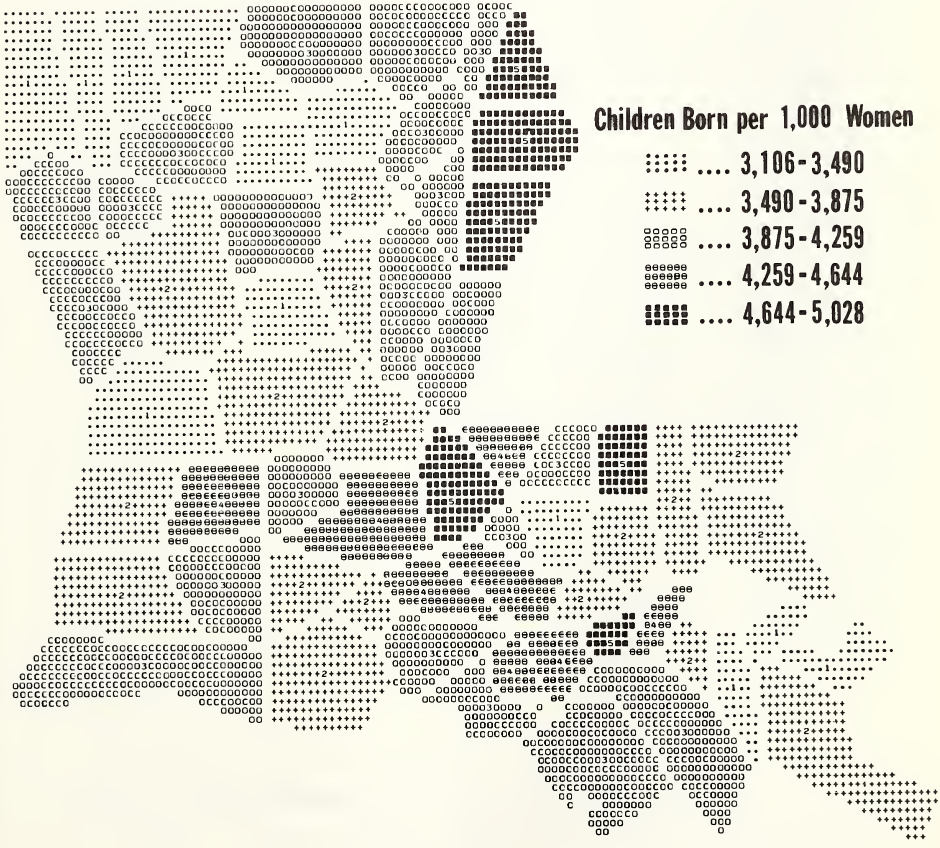

Figure 11.—Children ever born per 1,000 women ever married.

TABLE 8.-Children Ever Born to Women Age 35-44 Years for Coastal and Noncoastal Parishes, 1970

Parish	Total	Negro	White
COASTAL			
Acadia	3.806	4.854	3.577
Ascension	3.843	5.003	3.534
Assumption	4.559	5.779	3.977
Calcasieu	3.546	4.359	3.335
Cameron	4.000	--	4.028
East Baton Rouge	3.334	4.278	3.014
Evangeline	4.163	5.935	3.577
Iberia	4.108	5.195	3.774
Iberville	4.398	5.643	3.616
Jefferson	3.188	4.537	3.033
Jefferson Davis	3.942	4.619	3.755
Lafayette	3.647	4.660	3.424
Lafourche	3.959	5.693	3.802
Livingston	3.600	5.031	3.443
Orleans	3.422	4.031	2.913
Plaquemines	3.826	5.316	3.507
Pointe Coupee	4.703	5.925	3.690
St. Bernard	3.110	4.051	3.084
St. Charles	3.851	5.791	3.351
St. James	4.688	5.611	4.073
St. John the Baptist	4.397	4.820	4.056
St. Landry	4.315	5.528	3.647
St. Martin	4.463	5.564	3.923
St. Mary	3.900	5.164	3.559
St. Tammany	3.543	5.168	3.268
Tangipahoa	3.700	5.121	3.153
Terrebonne	4.021	5.610	3.799
Vermilion	3.858	4.791	3.734
West Baton Rouge	4.014	4.813	3.449
Total Coastal	3.592	4.539	3.269

(continued)

TABLE 8.-(continued)

Parish	Total	Negro	White
NONCOASTAL			
Allen	4.135	5.610	3.773
Avoyelles	3.859	5.225	3.473
Beauregard	3.671	5.319	3.251
Bienville	3.909	4.990	3.083
Bossier	3.227	5.274	2.954
Caddo	3.219	4.254	2.766
Caldwell	3.842	5.721	3.071
Catahoula	4.202	6.701	3.420
Claiborne	3.402	4.307	2.690
Concordia	3.900	5.721	3.260
DeSoto	4.168	5.304	3.156
East Carroll	5.028	6.661	3.425
East Feliciana	4.008	4.880	2.846
Franklin	4.069	6.192	3.115
Grant	3.309	4.579	3.062
Jackson	3.389	4.795	2.762
LaSalle	3.626	5.317	3.463
Lincoln	3.106	3.462	2.893
Madison	4.687	6.128	3.386
Morehouse	3.944	5.644	3.143
Natchitoches	3.830	5.352	3.012
Ouachita	3.259	4.446	2.882
Rapides	3.592	4.701	3.209
Red River	4.208	5.325	3.300
Richland	4.027	6.587	3.072
Sabine	4.125	5.178	3.829
St. Helena	4.802	5.729	3.681
Tensas	4.837	6.515	3.133
Union	4.047	5.841	3.185
Vernon	3.224	3.368	3.210
Washington	3.642	4.826	3.192
Webster	3.262	4.230	2.937
West Carroll	4.071	7.362	3.430
West Feliciana	4.582	5.741	3.380
Winn	3.923	6.044	3.139
Total Noncoastal	3.576	4.919	3.059

Source: Table 120 and 125, U.S. Bureau of the Census, Census of Population: 1970, General Social and Economic Characteristics, Final Report PC(1)-C20, Louisiana.

The strong French-Catholic ethnic group in the coastal region is characterized by cultural practices undoubtedly related to water resources. Members of this group became water oriented from the beginning and placed their settlements in such a way as to take advantage of bayous and other available water transportation routes. They also very early came to rely upon the coastal water areas as a source of food and livelihood. Utilization of fish and other wildlife for food led to a unique food culture, internationally recognized for consumption of crawfish, which is of interest in a report such as this because of the potential for development projects which it represents.

The existence of a French subculture, in addition to a black subculture, has implications for the planner. The local use of French as a language suggests that program implementers should consider using persons who are bilingual. It seems logical to assume that local beliefs and practices would differ from those found in non-French communities. Planners for the region will have to work out ways of becoming accepted by the local people.

The most striking finding of the demographic section of this study is that the coastal zone, originally defined in terms of drainage patterns, can also be delineated in terms of the French-Catholic cultural area of Louisiana. There are some exceptions, such as East Baton Rouge Parish and its vicinity, but these are not of great importance. The correspondence of a cultural and a physical area is not unusual. However, it is a coincidence which always has challenging consequences for the formulation of policies and programs.[8]

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[8] For a discussion of this in the context of agricultural planning, see *The French and Non-French in Rural Louisiana*, Alvin L. Bertrand and Calvin L. Beale, LAES Bulletin No. 606, December 1967.

Industrial and Occupational Milieu

The human resource component in an area is reflected in occupational and industrial activity as well as in the composition and distribution of the population. It was with this thought in mind that selected data relating to industry and employment were gathered. It can be seen from the accompanying tables and charts that there is, indeed, an important difference in the way people make a living in the coastal and noncoastal areas. These differences can be highlighted in terms of the percentage of persons in at least two employment categories, agriculture and mineral production (see Table 9 and Figure 12). It should be noted that a previous Sea Grant publication has explored differences in the economic structure of the coastal and noncoastal areas.[9] For this reason, only broad findings which reflect culturally relevant patterns are reviewed here.

One such pattern is that significantly fewer persons are engaged in agriculture in the coastal zone than in the noncoastal area. This difference is in both relative and absolute terms, as can be seen in Figure 13 and Table 10. The full ramifications of this difference in the way a living is made in the two regions are not obvious without elaboration.

First, although it is clear that agricultural pursuits occupy the time and interests of more persons in the noncoastal area, only a relatively small percentage of persons work on farms in either the coastal zone or the noncoastal region. In this regard, it should be noted that many persons are engaged in farm-related but off-farm occupational pursuits. But it is still clear that noncoastal areas are much more agriculture-oriented in the traditional sense. A recent study done at the request of the Louisiana Advisory Commission on Coastal and Marine Resources goes into considerable detail in this area.[10]

Second, there is a considerable difference in agriculturally related pursuits in the two parts of the state. Coastal area farmers tend to specialize in crops not grown in great quantity in noncoastal areas, such as rice, sugarcane, winter vegetables, and citrus. They also are engaged to a much greater extent in fisheries and trapping activity. Since fishing activity is included under agricultural industries in the U.S. Census, it was deemed of interest to try to determine the extent of its importance in the coastal area. Certain indicators were found and are shown in Table 11.

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[9] Lamar B. Jones and G. Randolph Rice, *An Economic Base Study of Coastal Louisiana,* Center for Wetland Resources, Louisiana State University, Baton Rouge, LSU-SG-72-02.

[10] Floyd L. Corty, *Agriculture in the Coastal Zone of Louisiana,* Department of Agricultural Economics and Agribusiness, A.E.A. Information Series No. 25, Louisiana State University, Baton Rouge, May 1972.

TABLE 9.-Industry of Employed Persons for Selected Industries in Louisiana by Parish, 1970

Parish	Total Employed	Agriculture	Mining	Construction	Manufacturing	General Merchandising and Retailing
Coastal						
Acadia	15,009	1,750	1,374	1,083	1,678	295
Ascension	10,805	459	209	1,430	2,643	234
Assumption	4,929	937	219	569	1,081	66
Calcasieu	47,648	1,084	1,693	5,168	9,052	1,188
Cameron	2,601	336	416	219	306	58
East Baton Rouge	102,577	1,133	981	10,116	17,772	2,654
Evangeline	8,386	1,316	585	613	931	155
Iberia	17,346	1,090	2,673	1,076	2,242	495
Iberville	8,018	548	363	1,088	1,361	81
Jefferson	122,345	1,129	4,810	10,608	19,323	4,168
Jefferson Davis	8,752	1,391	930	731	763	204
Lafayette	37,569	1,380	3,568	2,926	2,030	1,220
Lafourche	20,964	1,362	2,191	1,789	3,193	441
Livingston	11,066	432	183	2,091	1,986	273
Orleans	208,787	1,364	3,576	12,061	24,830	6,189
Plaquemines	7,905	371	1,596	1,015	827	76
Pointe Coupee	5,510	844	66	913	707	129
St. Bernard	17,521	225	356	1,785	3,777	520
St. Charles	8,910	205	261	723	2,881	216
St. James	4,976	511	18	313	2,197	40
St. John the Baptist	6,321	312	94	660	2,293	111
St. Landry	20,569	2,362	1,335	2,901	1,337	250
St. Martin	8,301	991	696	1,316	717	133
St. Mary	19,130	1,120	2,347	1,491	2,647	334
St. Tammany	19,608	440	488	2,065	4,018	351
Tangipahoa	19,294	2,007	292	1,939	3,063	438
Terrebonne	22,958	1,036	4,255	1,465	2,698	719
Vermilion	12,519	1,619	1,442	1,208	1,001	194
West Baton Rouge	4,583	309	68	617	1,070	88
Total	804,907	28,063	37,085	69,979	118,424	21,320

(continued)

TABLE 9.-(continued)

Parish	Total Employed	Agriculture	Mining	Construction	Manufacturing	General Merchandising and Retailing
Noncoastal						
Allen	5,676	418	146	551	1,337	147
Avoyelles	9,859	1,435	241	1,361	877	181
Beauregard	6,454	212	187	683	1,187	317
Bienville	4,677	269	137	413	1,578	55
Bossier	17,879	558	539	1,093	3,326	671
Caddo	82,576	1,368	2,977	5,280	14,916	2,191
Caldwell	2,700	351	111	283	362	48
Catahoula	3,091	596	188	306	371	35
Claiborne	5,001	269	364	323	1,195	93
Concordia	6,807	701	540	505	1,057	182
DeSoto	6,439	563	167	428	1,768	120
East Carroll	3,067	867	34	179	171	77
East Feliciana	4,419	309	18	350	854	31
Franklin	6,319	1,360	167	518	665	168
Grant	3,619	291	184	405	566	56
Jackson	5,250	116	18	349	2,228	437
LaSalle	3,810	84	606	253	907	31
Lincoln	11,371	342	220	733	1,248	214
Madison	4,015	750	23	263	527	101
Morehouse	9,038	971	77	531	2,655	207
Natchitoches	10,081	779	160	846	754	101
Ouachita	39,340	692	402	3,083	6,069	1,385
Rapides	35,353	1,505	406	2,501	4,329	976
Red River	2,715	340	67	240	574	36
Richland	5,849	1,037	166	558	786	108
Sabine	4,812	247	214	373	1,371	59
St. Helena	2,429	332	60	330	356	7
Tensas	2,388	707	62	103	181	30
Union	5,565	318	153	525	1,477	76
Vernon	6,933	246	63	607	738	275
Washington	12,636	646	260	959	3,495	177
Webster	13,369	265	361	873	4,988	260
West Carroll	3,228	768	36	390	439	74
West Feliciana	1,745	137	16	72	543	21
Winn	4,828	87	129	363	1,755	81
Total	353,338	19,936	9,499	26,630	32,150	9,028

Source: Table 123, U.S. Bureau of the Census, Census of Population: 1970, General Social and Economic Characteristics, Final Report PC(1)-C-20, Louisiana.

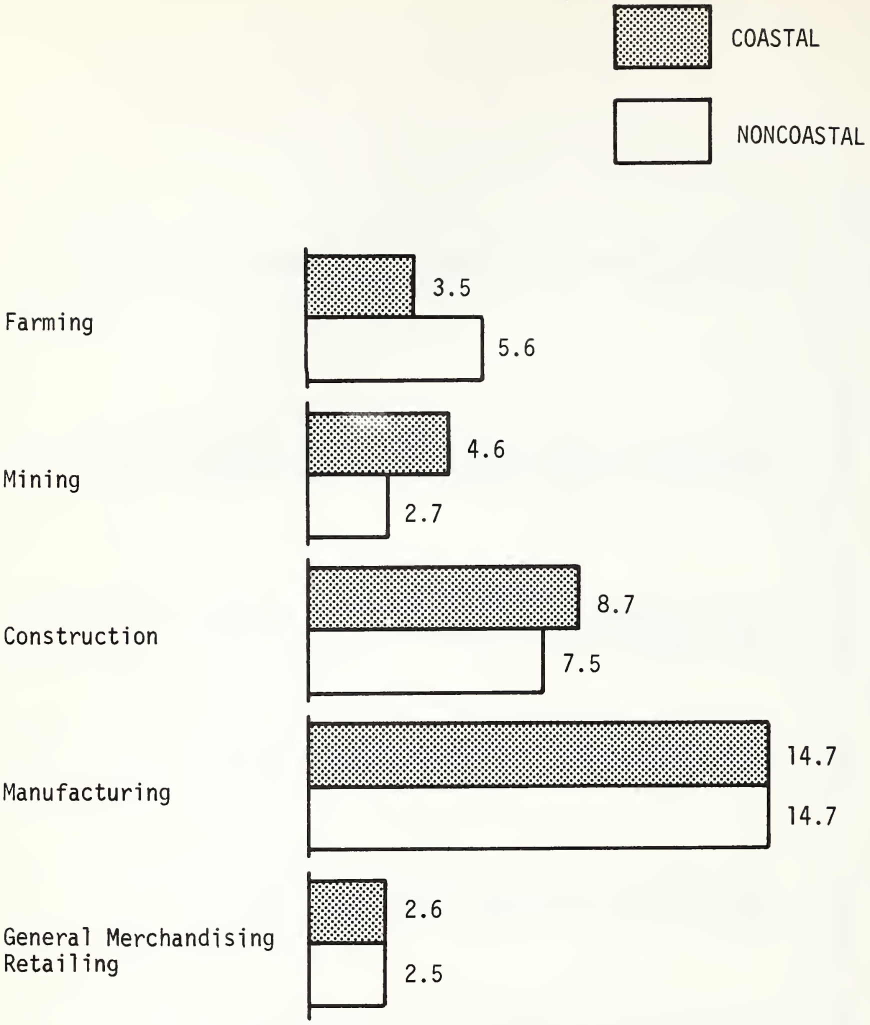


Figure 12.—Percent distribution of employed persons for selected industries in the coastal and noncoastal areas of Louisiana, 1970.

Source: U.S. Bureau of the Census, Census of Population: 1970, General Social and Economic Characteristics, Final Report PC(1)-C-20 Louisiana, Table 123.

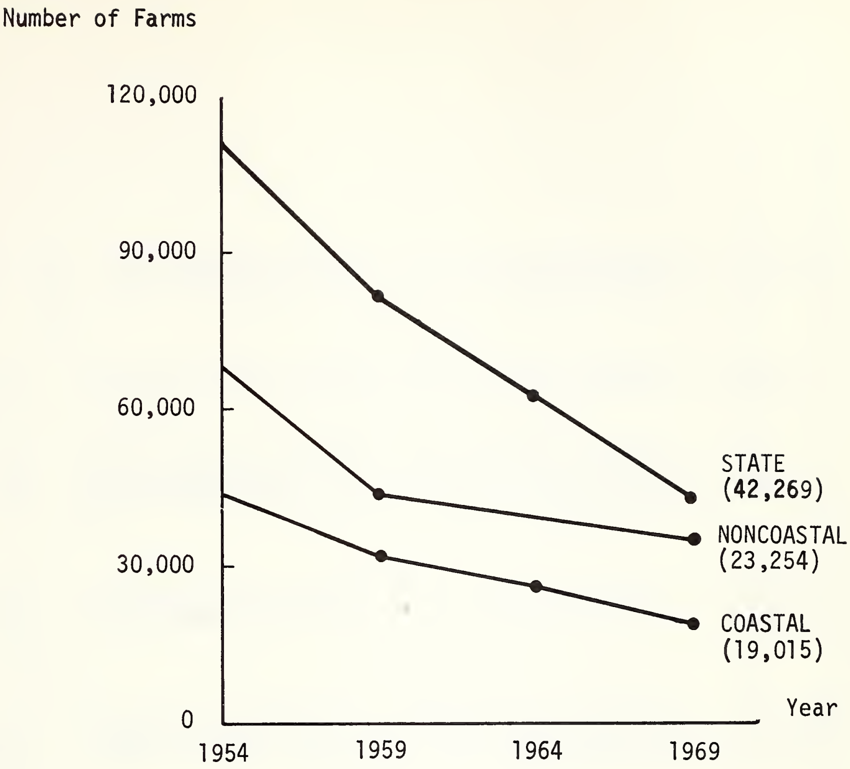


Figure 13.—Number of farms in Louisiana, the coastal zone, and the noncoastal area, 1954-1969.

Sources: U.S. Bureau of the Census, Census of Agriculture: 1969, Vol. 1, Part 35, La. Section 2, County Data, Table 3; U.S. Census of Agriculture: 1959, Vol. 1, Table 2.

TABLE 10.-Farms, Land in Farms and Ownership in Louisiana by Parishes, 1969

Parish	Approximate Land Area--Acres	Land in Farms, Acres	Number of Farms	Average Size of Farm--Acres	Proportion in Farms, Percent	Tenant Acres	Percent of Tenancy	Negro Percent of Tenancy
Coastal								
Acadia	424,192	335,630	1,453	230.9	79.1	72,141	21.8	37.3
Ascension	192,640	64,135	523	308.0	33.3	18,753	14.3	50.0
Assumption	227,584	84,743	194	436.8	37.2	33,719	48.4	60.0
Calcasieu	707,200	403,435	739	545.9	57.0	109,686	25.1	33.3
Cameron	922,368	287,385	423	679.3	31.2	34,454	13.7	0.0
East Baton Rouge	293,760	133,511	675	197.7	45.4	16,854	12.8	15.3
Evangeline	427,840	222,317	1,519	146.3	52.0	32,336	23.6	62.7
Iberia	376,960	131,051	591	221.7	34.8	29,442	24.5	36.5
Iberville	401,472	122,340	286	427.7	30.5	35,700	40.9	40.7
Jefferson	236,416	8,951	54	165.7	3.8	2,788	31.4	0.0
Jefferson Davis	420,864	365,769	897	407.7	86.9	115,800	31.9	33.3
Lafayette	181,120	136,453	1,452	93.9	75.3	26,932	19.6	39.2
Lafourche	730,048	204,629	519	394.2	28.0	47,481	31.2	0.0
Livingston	418,368	44,864	489	91.7	10.7	824	2.8	33.3
Orleans	126,144	-	-	-	-	-	-	-
Plaquemines	658,944	31,691	111	285.5	4.8	4,926	25.2	50.0
Pointe Coupee	360,448	228,458	811	281.6	63.4	43,489	31.4	52.6
St. Bernard	329,024	7,112	27	263.4	2.2	320	25.9	0.0
St. Charles	188,224	33,653	71	473.9	17.9	18,645	47.8	0.0
St. James	162,112	56,900	145	392.4	35.1	28,948	45.5	43.4
St. John the Baptist	145,024	22,556	47	479.9	15.6	3,177	40.4	78.5
St. Landry	596,480	336,329	2,864	117.4	56.4	54,265	23.7	39.9
St. Martin	471,040	99,532	774	128.5	21.1	25,114	30.6	56.0
St. Mary	399,040	121,199	216	561.1	30.4	38,802	36.1	26.8
St. Tammany	567,360	80,206	526	152.4	14.1	2,665	4.7	0.0
Tangipahoa	517,184	159,592	1,513	105.4	30.9	7,851	6.0	9.4
Terrebonne	875,200	100,080	217	461.1	11.4	17,771	27.6	50.0
Vermilion	771,328	393,113	1,738	226.1	51.0	57,818	19.4	48.7
West Baton Rouge	129,856	55,334	141	392.4	42.6	10,728	23.4	12.5
Total	12,132,096	4,270,968	19,015	224.6	35.0	891,429	21.0	

(continued)

TABLE 10-(continued)

Parish	Approximate Land Area--Acres	Land in Farms, Acres	Number of Farms	Average Size of Farm--Acres	Proportion in Farms, Percent	Tenants Acres	Percent of Tenancy	Negro Percent of Tenancy
Noncoastal								
Allen	495,488	161,088	523	308.0	32.5	25,595	12.4	13.3
Avoyelles	532,480	257,609	2,009	128.0	48.4	14,975	10.0	22.6
Beauregard	757,568	157,174	828	189.8	20.7	15,546	6.8	0.0
Bienville	532,608	95,396	548	174.0	17.9	3,624	5.2	5.1
Bossier	543,040	181,350	537	337.7	33.4	26,582	13.5	13.0
Caddo	575,296	277,386	807	343.7	48.2	46,942	18.4	16.8
Caldwell	352,448	61,375	333	184.3	17.4	7,588	10.2	17.9
Catahoula	474,944	204,071	671	304.1	43.0	61,945	13.5	21.2
Claiborne	488,448	113,677	535	212.4	23.3	8,081	8.7	12.6
Concordia	459,264	237,946	443	537.1	51.8	34,358	16.4	22.0
DeSoto	572,160	246,552	877	281.1	43.1	25,166	10.3	11.6
East Carroll	278,720	211,010	445	474.1	75.7	34,071	18.2	15.9
East Feliciana	290,496	184,764	503	367.3	63.6	11,395	11.1	14.9
Franklin	414,528	326,782	1,701	192.1	78.8	47,840	15.5	29.5
Grant	428,608	62,796	347	180.9	14.7	1,793	8.0	21.6
Jackson	372,544	29,063	232	125.2	7.8	450	3.0	33.3
LaSalle	411,648	21,695	283	76.6	5.3	1,245	7.4	38.4
Lincoln	300,032	77,333	482	160.4	25.8	2,683	3.9	21.4
Madison	423,232	242,575	443	547.5	57.3	44,873	17.8	33.7
Morehouse	514,560	268,449	726	369.7	52.2	45,413	16.3	18.8
Natchitoches	828,800	267,807	881	303.9	32.3	21,715	10.4	18.9
Ouachita	408,064	111,771	499	223.9	27.4	8,540	12.2	25.0
Rapides	843,776	197,839	1,130	175.0	23.4	30,595	14.2	37.3
Red River	259,776	131,513	428	307.2	50.6	13,427	11.2	26.3
Richland	368,832	263,814	1,146	230.2	71.5	33,989	14.7	33.5
Sabine	558,720	82,557	566	145.8	14.8	1,050	1.5	40.0
St. Helena	268,800	71,249	594	119.9	26.5	2,990	5.2	4.6
Tensas	400,832	235,042	459	512.0	58.6	38,201	27.4	35.3
Union	579,840	89,885	574	156.5	15.5	2,781	5.0	12.2
Vernon	868,672	63,142	575	109.8	7.3	1,509	2.6	50.0
Washington	425,600	137,405	1,212	113.3	32.3	4,248	4.3	8.6
Webster	393,856	103,758	545	190.3	26.3	3,659	5.8	8.8
West Carroll	227,840	196,855	1,163	169.2	86.4	22,638	13.0	26.5
West Feliciana	259,136	121,455	221	549.5	46.9	9,256	31.6	57.1
Winn	608,256	25,511	218	117.0	4.2	605	4.5	0.0
Total	16,518,912	5,517,694	23,254	237.28	33.0	655,368	12.0	
State Total	28,777,152	9,788,662	42,269	231.5	34.0	1,546,797	16.0	29.6

Source: U.S. Bureau of the Census, Census of Agriculture, 1969, Vol. 1, Area Reports, Part 34, Louisiana 2; County Data, U.S. Government Printing Office, Washington, D.C., 1972.

TABLE 11.-Fishing and Trapping Activities in Louisiana

NUMBER OF FISHERMEN, QUANTITY AND VALUE OF LANDINGS IN LOUISIANA, 1972, AND NUMBER OF PROCESSING PLANTS IN LOUISIANA, 1971*

	Number of Fishermen 1972		Quantity and Value of Landings, 1972		Processing Plants and Number of Employees, 1971	
	Full Time	Part Time	Quantity 1000 of Pounds	Value 1000 of Dollars	Number of Plants	Average Annual Employment
Louisiana	9,500	3,300	1,070,597	71,916	128	3,112
Gulf States	30,500	8,250	1,584,799	232,419	428	11,488
United States	85,730	64,180	4,710,400	703,600	1,836	56,698

NUMBER OF TRAPPING AND FUR DEALING LICENSES SOLD FOR COASTAL AND NONCOASTAL LOUISIANA**

	Trapping	Fur Buyers	Fur Dealers
Coastal Total	2,520	73	14
Noncoastal Total	878	12	2
Louisiana Total	3,398	85	16

*Source: United States Department of Commerce, Fisheries of the United States, 1972, March 1973.

**Source: Louisiana Almanac, 1973-1974, p. 215.

Information obtained on commercial fishing activities in the state shows there were 128 fish processing plants in Louisiana in 1971, and that there were 9,500 full-time and 3,300 part-time commercial fishermen in 1972. The great majority of these plants and fishermen are in the coastal area. An idea of the importance of this type activity can be gleaned from the fact that, in 1972, Louisiana led all states in volume of fish landings with over 1 billion pounds processed. Shell fish are also a very important commodity in the coastal zone. The areas where oysters, crabs, and saltwater fish are caught appear in Figure 14. For example, approximately 58 million pounds of shrimp with a value of $43.3 million were harvested in Louisiana coastal waters in 1971 (Table 12).

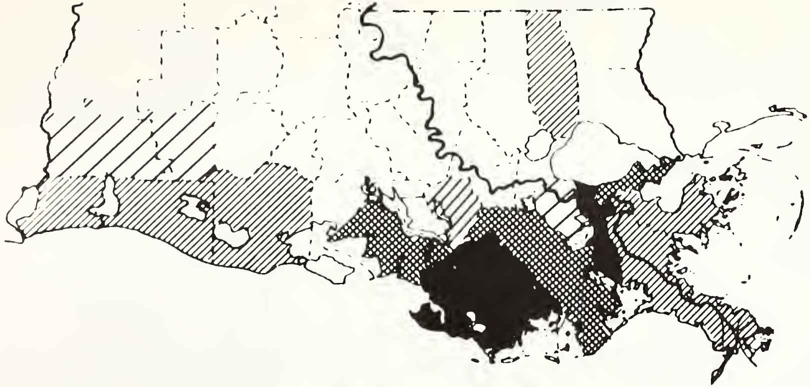
It is also of interest to note the large number of trapping licenses sold in the coastal zone—2,520 as compared with only 878 in the noncoastal area. Fur-bearing animals such as nutria and muskrat thrive in the marsh and swamp lands of the coastal zone and provide a source of income for many residents in parishes such as Terrebonne, Vermilion, St. Mary, and Cameron (Table 11). Since most commercial fishing and trapping activities are restricted to the coastal zone, one can expect a definite cultural distinction in this respect between coastal and noncoastal Louisiana.

It also should be noted that seafood and fur represent renewable resources. These resources, if properly maintained, could become increasingly important segments of the state's economy.

The third difference in agricultural pursuits between the coastal and noncoastal zones is with respect to land holdings and tenure. There has been a decrease in the number of acres in farming in both coastal and noncoastal areas, but the drop in acreage has been more rapid in the noncoastal part of the state (see Figure 15). The number of farms also has been dropping in both regions, but this trend is more evident in the coastal parishes. From 1954 to 1969, the number of farms in Louisiana declined by 62 percent (Figure 13). The number of farms in the coastal zone declined by 56 percent and in the noncoastal area by 66 percent during this same period. Average farm size in the coastal zone was 110 acres in 1954, as compared with 99 acres in the noncoastal area; by 1969 average farm size had increased to 225 acres in the coastal zone and 237 acres in the noncoastal area. These changes are portrayed graphically in Figure 16.

Land tenure has reference to the relations which man has to the land he owns or works. In this context, tenant farming is still a major way of life for many residents in the coastal zone. In fact, over two-thirds of the coastal zone farm acres are worked by tenants. By comparison, less than half the acreage in the noncoastal area is operated by tenants (Table 10). This pattern probably reflects a trend on the part of coastal landowners to maintain ownership, even though they live off the farm themselves. Such decisions can be attributed in part to a hope for benefits from oil and gas deposits.

SEA FOOD PROCESSING, NUMBER EMPLOYEES

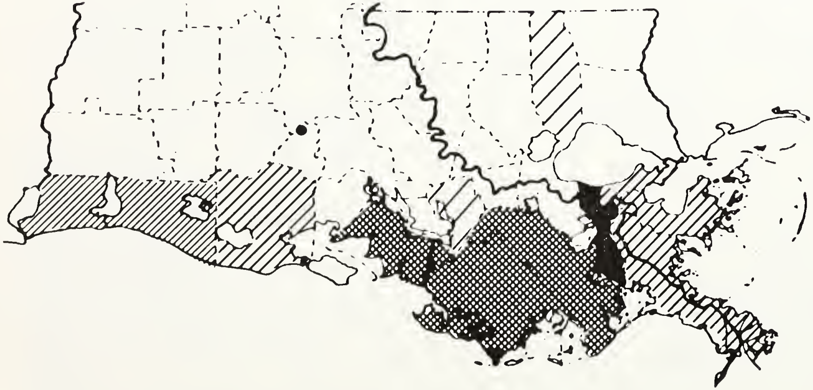


Peak of season, 1967

■	1,173-1,269
▩	360-411
▨	188-282
▨	45
▨	3-19

State = 4,882

PROCESSED PRODUCTS



1967 Value
X $1000

■	18,209
▩	9,166-11,516
▨	6,275
▨	2125-3,695
▨	44-994

State = 68,160

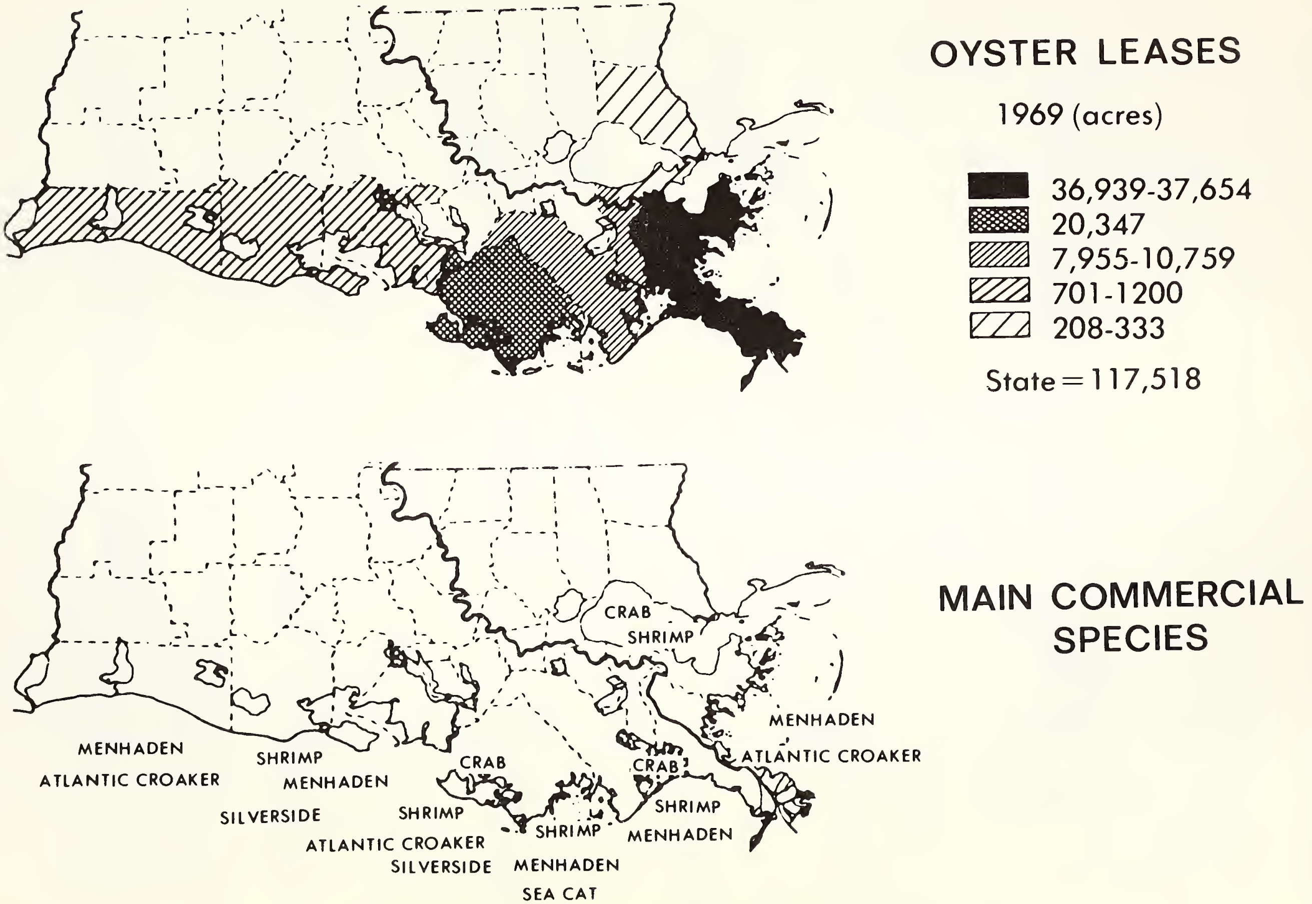


Figure 14.—Seafood processing industry in Louisiana.

TABLE 12.-Gulf Coast States Summary of Shrimp Landings, 1971

	Quantity 1000 of Pounds	Value 1000 of Dollars
Louisiana	58,712	43,283
Florida West Coast	13,580	12,985
Alabama	10,470	11,451
Mississippi	5,927	4,239
Texas	54,385	64,191

Source: U.S. Department of Commerce, Current Fisheries Statistics No. 5924, Shrimp Landings, Annual Summary 1971, pp. 2-3.

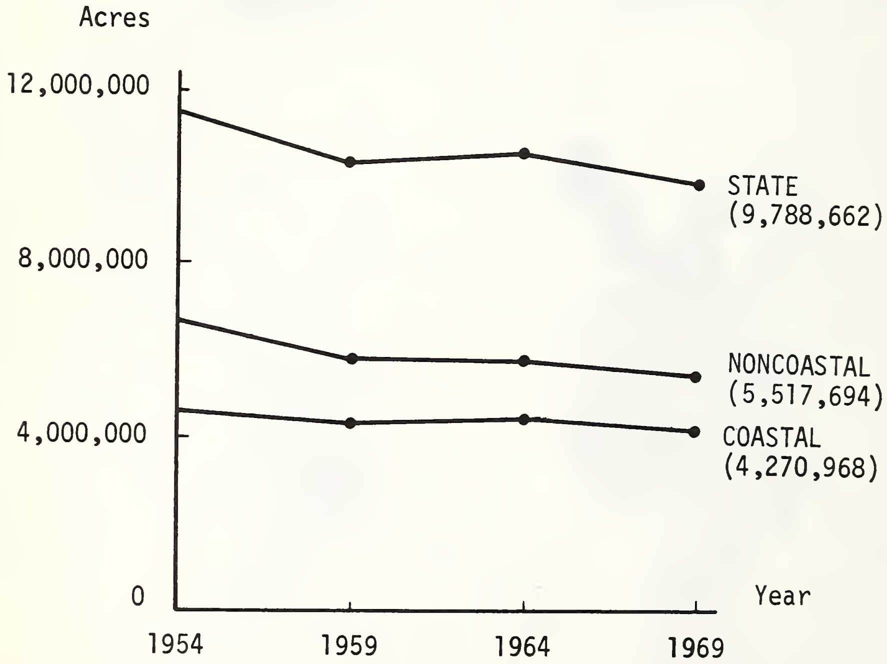


Figure 15.—Land in farms in Louisiana, the coastal zone, and the noncoastal area, 1954-1969.

Sources: U.S. Bureau of the Census, Census of Agriculture: 1969, Vol. 1, Area Reports, Part 35, La. Section 2, County Data, Table 1; U.S. Census of Agriculture: 1959, Table 2.

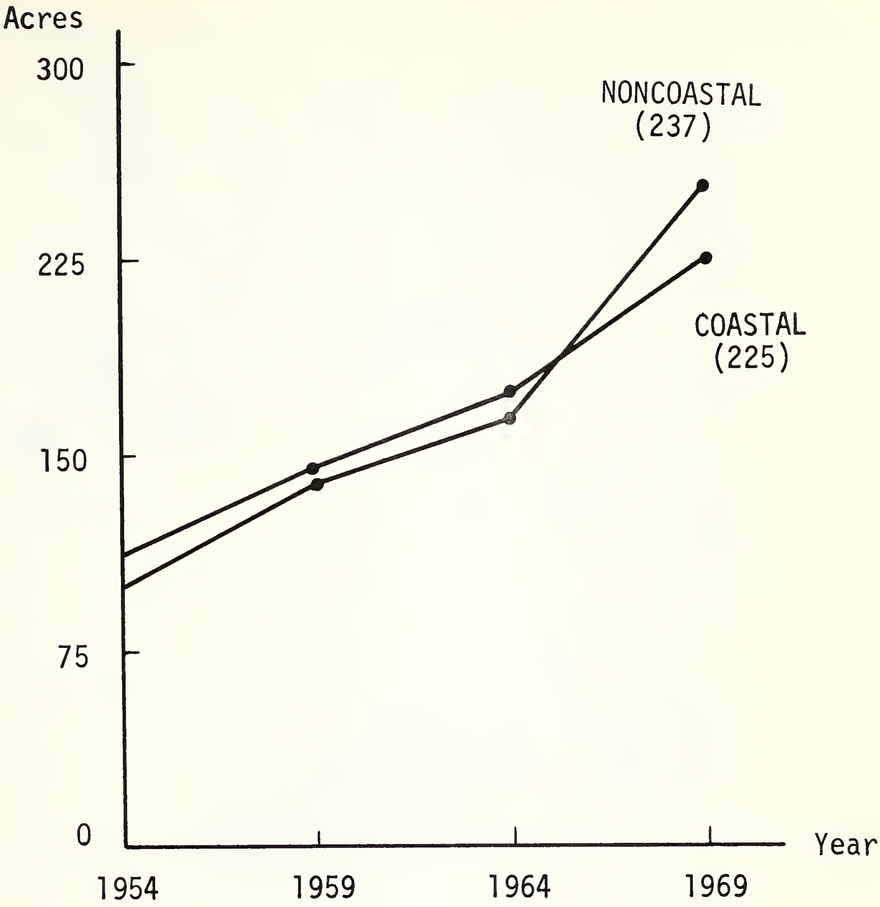


Figure 16.—Average size of farm in Louisiana's coastal zone and noncoastal area, in acres, 1954-1969.

Sources: U.S. Bureau of the Census, Census of Agriculture: 1969, Vol. 1, Area Reports, Part 35, La. Section 2, County Data, Table 3; U.S. Census of Agriculture: 1959, Vol. 1, Table 2.

The second major occupational activity which varies considerably from coastal to noncoastal Louisiana is mineral production or mining. The map of mineral production in Louisiana for 1969 (Figure 17) shows the vast areas of the coastal zone where mines are located. The leading minerals produced are salt, sulphur, lime, gypsum, and oil. Oil and gas production, which has a market value of more than $4.32 billion annually, is the major mineral industry in the coastal zone. Despite the fact that crude oil production in Louisiana experienced a sharp decline in 1971

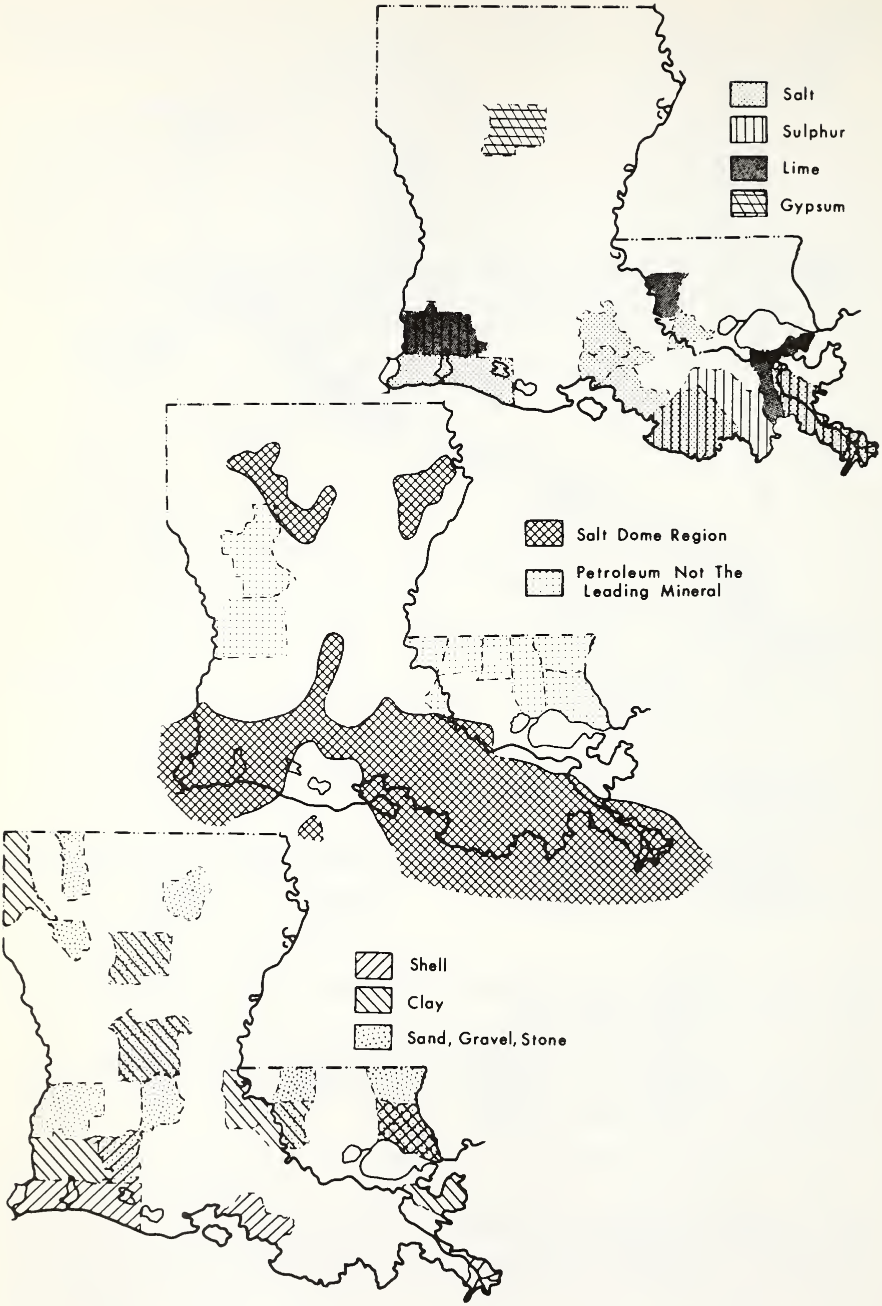


Figure 17.—Mineral production in Louisiana, 1969.

(Figure 18), and that this decline occurred primarily in the coastal zone, production there still remains high.

Mining, including quarrying as well as petroleum and gas extraction, currently employs over 37,000 people in the coastal zone, which is more than three times the number employed in like occupations in the noncoastal area (Table 9). In fact, almost one out of every 20 persons is

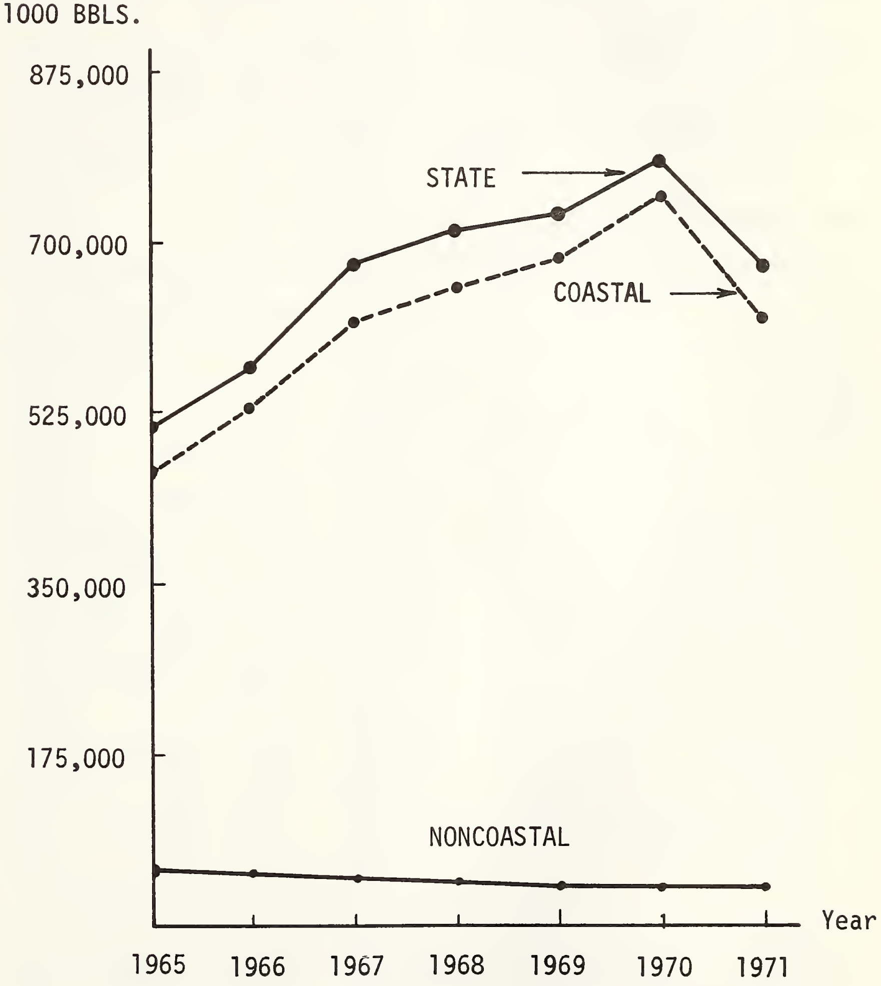


Figure 18.—Crude oil production in Louisiana, the coastal zone, and the noncoastal area, 1965-1971.

Source: Louisiana Department of Conservation, Annual Oil and Gas Report, respective years.

employed in this type occupation in the coastal zone, but in the noncoastal area only one in about every 34 persons is working in a mineral or mining job. The difference in the amount of such activity carried on in each region is highlighted by the fact that the value of mineral production was approximately 10 times greater in the coastal zone than in the noncoastal area in 1968 (see Table 13).

Figure 12 and Table 9 include information on persons employed in construction, in manufacturing, and in general merchandising and retailing in the coastal and noncoastal areas of Louisiana. These occupational areas, along with agriculture and mining, were considered to represent the important employment opportunities in the state where differences between coastal and noncoastal areas might exist. It can be seen that there is some difference between the coastal and noncoastal regions in the relative number of persons employed in construction work.

TABLE 13.-Value of Mineral Production in Louisiana, by Parish, 1967 and 1968

Parish	1967	1968	1968 Minerals Produced in Order of Value[1]
Coastal			
Acadia	$ 138,834	$ 114,116	NG, NGL, P
Ascension	33,288	10,117	P, S, NG
Assumption	32,752	27,708	NG, P
Calcasieu	72,037	62,882	P, NG, NGL, L, S, CM, SL, C
Cameron	176,593	218,472	NG, P, NGL, S, ST
East Baton Rouge	18,917	16,689	CM, L, P, S&G, NG, C
Evangeline	13,608	11,022	P, NG, NGL, S&G
Iberia	144,428	193,098	P, NG, S, NGL, C
Iberville	64,781	53,620	P, S, NG, NGL
Jefferson	144,309	220,804	P, SL, NG, S, NGL, ST
Jefferson Davis	80,786	57,825	NG, P, NGL, S&G
Lafayette	19,992	15,872	NG, P, NGL, C
Lafourche	315,272	445,289	P, NG, SL, NGL
Livingston	67	18	P, NG
Orleans	15,262	15,372	C, L, NG
Plaquemines	912,908	1,093,662	P, NG, SL, NGL, S
Pointe Coupee	22,668	25,087	P, NG, NGL, C
St. Bernard	19,537	32,225	NGL, P, NG, C
St. Charles	88,875	74,516	P, NGL, NG
St. James	10,064	10,382	P, NG, NGL
St. John the Baptist	6,482	4,703	P, NG, ST
St. Landry	56,187	49,302	NG, P, NGL
St. Martin	101,274	80,464	P, NG, NGL, S
St. Mary	328,346	346,074	P, NG, NGL, S, ST, L
St. Tammany	3,165	7,837	ST, S&G, NG, C, P
Tangipahoa	430	170	P, S&G, C
Terrebonne	535,504	529,991	P, NG, SL, NGL, S
Vermilion	153,895	220,785	NG, P, NGL, S&G
West Baton Rouge	845	3,497	P, NG, C
Coastal Total	3,511,106	3,941,599	

(Continued)

This difference, no doubt, is related to the fact that coastal areas are growing at a faster rate than the rest of the state. However, about the same relative number of people are employed in manufacturing, in general merchandising and retailing, and in other activities in both regions of the state.

TABLE 13.-(continued)

Parish	1967	1968	1968 Minerals Produced in Order of Value[1]
Noncoastal			
Allen	$ 7,903	$ 6,361	P, NG, NGL
Avoyelles	6,627	5,449	P, NGL, NG
Beauregard	14,494	9,315	P, NGL, NG, S&G
Bienville	12,332	7,293	NG, P, C
Bossier	20,137	24,005	NG, P, NGL
Caddo	28,525	26,324	P, NG, NGL, C
Caldwell	2,502	1,914	NG
Catahoula	17,501	9,513	P, S&G, NG
Claiborne	34,784	27,054	P, NG, NGL
Concordia	37,534	30,011	P, NG
DeSoto	12,878	6,458	NG, P
East Carroll	-	28	NG
East Feliciana	D	D	S&G
Franklin	4,119	2,188	P, NG
Grant	462	2,272	P, S&G, NG
Jackson	4,251	2,650	NG, P
LaSalle	29,925	19,733	P, NG, S&G
Lincoln	35,732	19,835	NGL, NG, P, C
Madison	1,955	814	NG
Morehouse	1,891	11,760	NG, NGL, P
Natchitoches	30,425	33,227	P, NG, NGL, C
Ouachita	11,360	24,791	P, NG, NGL, S&G
Rapides	10,499	7,548	P, S&G, NG, NGL, C
Red River	1,581	595	S&G, P, NG
Richland	22,346	16,911	P, NGL, NG
Sabine	14,226	3,743	P, NG
St. Helena	D	D	S&G
Tensas	18,491	7,359	P, NGL, NG
Union	7,991	2,114	NG, P
Vernon	17	17	S&G
Washington	621	928	S&G
Webster	36,959	31,635	NG, NGL, P, S&G
West Carroll	139	36	NG
West Feliciana	D	D	S&G
Winn	2,439	2,823	P, G, ST, S&G
Undistributed	19,998	16,707	
Noncoastal Total	450,644	379,411	
State Total	3,961,750	4,321,010	

[1] P=Petroleum, NG=Natural Gas, NGL=Natural Gas Liquid, S&G=Sand and Gravel, S=Salt, L=Lime, C=Clays, CM=Cement, SL= Sulfur, ST=Stone, G=Gypsum.

D--Figures withheld to avoid disclosing company confidential data.

Source: Division of Business and Economic Research, College of Business Administration, Louisiana State University in New Orleans, Statistical Abstract of Louisiana. Fourth Edition, 1971.

In concluding this section on major occupational and employment differences which set coastal Louisiana apart from noncoastal Louisiana, a word of summary is in order. Coastal residents are less likely to be farmers than noncoastal residents. However, those occupied in agricultural industries will tend to be in types of pursuits which are not prevalent in the northern part of the state. Another contrast is that coastal residents are more likely to be employed in extractive industries, i.e., mining and mineral production. These differences set the stage for considerable sociocultural differences between the two areas.

The Recreation Picture and Potential of the Coastal Zone

Coastal areas of Louisiana represent an unusual recreation resource, with the mild climate and abundance of fish and wild life in these areas. It is thus important to attempt to determine the recreation use now being made of Louisiana's coastal zone. It is also in keeping with the objectives of this study to determine the potential uses for recreation which the coastal zone might have. The following discussion is intended to provide an indication of how the coastal zone fits into the statewide recreation picture.

Two recreation activities, fishing and hunting, are more popular in Louisiana than in the U.S. as a whole. These are traditional sports engaged in by thousands of persons because the state offers many acres of woodlands, swamps, marshes, agricultural lands, and water areas rich in fish and game. Rather easy access to game areas, as well as to fresh-water and salt-water fishing, enhances participation in these activities.

Differences in sports fishing and hunting activity between the coastal and noncoastal areas are principally related to the presence of the Gulf of Mexico and to the terrain features in these two parts of the state. For example, charter boats out of several coastal ports make daily recreation fishing runs as far as 20 to 30 miles to the large oil and gas platforms which dot the offshore Gulf area. Smaller, privately owned boats provide access to literally hundreds of bayous and lakes which characterize the estuarine areas of southern Louisiana. These areas also account for the national reputation which the Louisiana coast has for duck and goose hunting. In contrast, the noncoastal areas are more popular for deer and for birds other than waterfowl.

Empirical evidence showing the larger volume of hunting and fishing in the coastal region as contrasted to the noncoastal region is presented in Table 14. It can be seen that over 30,000 more resident fishing licenses were sold in the coastal parishes in 1971, and that 35,000 more hunting licenses were sold.

There are, of course, many other outdoor recreation activities, besides fishing and hunting, which are popular in Louisiana. Among those which stand out are boating for pleasure, camping, picnicking, bicycling, swimming, and sightseeing. It should be of concern to planners for the state that

TABLE 14.--Licenses Sold by Parish 1970-71 Hunting and Fishing Season

	Hunting					Fishing		
Parish	Basic Resident $2.00	N/R Season $25.00	N/R Trip $5.00	Recip-rocal	Big Game $2.00	Resident $2.00	N/R Season $6.00	N/R Trip $3.00
Coastal								
Acadia	4,919	1	82	12	453	1,013	2	10
Ascension	3,883	1	6	-	1,068	1,106	2	25
Assumption	1,764	-	-	-	355	386	-	3
Calcasieu	18,779	15	1,292	-	4,726	9,295	25	184
Cameron	1,674	179	820	56	123	4,149	6	70
East Baton Rouge	22,381	4	212	41	8,662	10,621	20	336
Evangeline	4,345	-	13	-	1,192	1,374	3	27
Iberia	5,015	-	42	9	667	2,468	15	75
Iberville	3,419	1	4	-	1,518	1,731	2	14
Jefferson	15,198	1	54	17	1,868	7,084	12	77
Jefferson Davis	4,455	3	270	47	586	1,075	5	20
Lafayette	9,178	7	225	-	1,378	3,323	4	81
Lafourche	8,182	-	-	-	805	2,037	6	3
Livingston	5,745	1	9	-	2,764	1,119	-	21
Orleans	17,084	4	278	42	2,229	20,266	70	250
Plaquemines	2,175	-	-	-	211	1,342	-	1
Pointe Coupee	2,369	-	27	-	1,197	1,076	6	48
St. Bernard	3,102	-	1	-	371	2,184	1	14
St. Charles	2,945	-	30	1	566	1,427	11	34
St. James	1,448	-	-	-	301	271	1	-
St. John the Baptist	1,680	-	7	-	342	535	3	15
St. Landry	8,916	-	32	-	2,635	2,876	3	30
St. Martin	2,819	-	6	-	486	1,606	4	59
St. Mary	6,158	1	71	-	1,048	2,034	14	61
St. Tammany	6,318	68	116	6	2,001	3,243	316	325
Tangipahoa	7,257	7	41	27	1,793	1,993	54	90
Terrebonne	7,956	6	21	-	696	3,266	6	18
Vermilion	5,199	7	479	-	592	1,307	3	11
West Baton Rouge	2,764	-	9	-	1,138	787	1	8
Total Coastal	187,127	306	4,147	258	41,771	90,994	595	1,210
Noncoastal	151,826	385	4,080	597	86,226	59,547	2,224	11,245
State Total	338,953	691	8.227	855	127,997	150,903	2,819	12,455

Source: Louisiana Almanac, 1973-74, p. 213.

Louisiana ranks below national participant averages in almost all these activities.[11] This is especially striking since the climate would allow for nearly year-round participation in outdoor recreation.

In comparing the coastal and noncoastal areas with regard to the above types of recreation, one fact stands out. The coastal parishes are far ahead of noncoastal parishes in user days in all of the activities studied and presented in Table 15. A considerable amount of this difference is directly related to population differentials, but in some instances the re-

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[11] U.S. Department of the Interior, Bureau of Outdoor Recreation, The 1970 Survey of Outdoor Recreation Activities, Preliminary Report, February, 1972, p. 8.

TABLE 15.- User Days of High Quarter* Participation by Recreation Activity for 1970 and Projected for 1985 by Parish

Coastal Parishes	Swimming 1970	Swimming 1985	Water Activities Non-fishing 1970	Water Activities Non-fishing 1985	Resource Based Recreation 1970	Resource Based Recreation 1985
Acadia	357,656	331,460	115,535	107,100	278,562	258,225
Ascension	249,112	353,971	80,492	114,374	194,071	275,763
Assumption	131,575	146,656	42,514	47,387	102,504	114,253
Calcasieu	1,006,531	1,254,711	325,226	405,417	784,143	977,488
Cameron	56,086	60,401	18,122	19,516	43,694	47,055
E. Baton Rouge	1,978,782	2,603,037	639,376	841,083	1,541,580	2,027,908
Evangeline	219,123	197,919	70,802	63,951	170,708	154,190
Iberia	389,511	402,791	125,857	130,098	303,451	313,674
Iberville	209,272	198,177	67,619	64,034	163,035	154,391
Jefferson	2,307,759	3,690,107	745,675	1,192,333	1,797,871	2,874,796
Jefferson Davis	203,893	175,956	65,881	56,854	158,844	137,079
Lafayette	753,223	1,027,500	243,378	332,002	586,802	800,479
Lafourche	462,949	556,008	149,586	179,655	360,662	433,161
Livingston	248,539	376,866	80,307	121,771	193,626	293,599
Orleans	4,162,608	4,132,705	1,345,006	1,335,344	3,242,900	3,219,604
Plaquemines	169,989	194,912	54,926	62,979	132,431	151,847
Pointe Coupee	150,876	134,934	48,751	43,599	117,540	105,121
St. Bernard	353,274	716,790	114,148	231,606	275,220	558,418
St. Charles	199,219	304,892	64,371	98,516	155,202	237,528
St. James	133,008	133,556	42,977	43,154	103,621	104,048
St. John	160,045	229,693	51,713	74,218	124,684	178,944
St. Landry	550,535	494,136	177,886	159,663	428,897	384,959
St. Martin	219,208	229,795	70,830	74,250	170,776	179,023
St. Mary	406,228	518,557	131,259	167,554	316,474	403,985
St. Tammany	438,222	997,644	141,596	322,355	341,399	777,219
Tangipahoa	455,432	486,353	147,157	157,148	354,806	378,895
Terrebonne	509,608	631,278	164,662	203,976	397,012	491,800
Vermilion	297,728	297,242	96,201	96,044	231,946	231,568
W.Baton Rouge	112,940	135,161	36,493	43,673	87,986	105,298
Coastal	16,971,142	21,013,207	5,483,651	6,789,707	13,221,451	16,370,442
Noncoastal	8,201,862	8,050,947	2,650,155	2,601,392	6,389,701	6,272,130
State	25,173,004	29,064,154	8,133,806	9,391,099	19,611,152	22,642,572

(continued)

TABLE 15.-(continued)

Coastal Parishes	Walking and Picnicking 1970	Walking and Picnicking 1985	Playing Outdoor Games 1970	Playing Outdoor Games 1985	Watching Outdoor Events 1970	Watching Outdoor Events 1985	Camping 1970	Camping 1985
Acadia	273,539	253,569	513,286	475,812	402,774	373,368	61,192	56,725
Ascension	190,572	270,790	357,601	508,127	280,608	398,726	42,632	60,577
Assumption	100,656	112,193	188,877	210,525	148,211	165,199	22,517	25,098
Calcasieu	770,002	959,862	1,444,879	1,801,143	1,133,793	1,413,352	172,254	214,727
Cameron	42,906	46,207	80,512	86,705	63,178	68,037	9,598	10,337
E. Baton Rouge	1,513,781	1,991,340	2,840,550	3,736,671	2,228,973	2,932,156	338,642	445,475
Evangeline	167,630	151,409	314,551	284,113	246,828	222,943	37,499	33,871
Iberia	297,978	308,018	559,145	577,983	438,760	453,542	66,660	68,905
Iberville	160,095	151,607	300,411	284,484	235,732	223,234	35,814	33,915
Jefferson	1,765,450	2,822,955	3,312,799	5,297,165	2,599,545	4,156,672	394,942	631,513
Jefferson Davis	155,980	134,607	292,690	252,585	229,673	198,203	34,894	30,112
Lafayette	576,220	786,044	1,081,254	1,474,980	848,457	1,157,413	128,904	175,843
Lafourche	354,159	425,350	664,565	798,152	521,482	626,308	79,227	95,153
Livingston	190,135	288,305	356,780	540,992	279,964	424,515	42,534	64,496
Orleans	3,184,422	3,161,546	5,975,442	5,932,517	4,688,915	4,655,231	712,375	707,257
Plaquemines	130,043	149,109	244,020	279,797	191,482	219,556	29,091	33,357
Pointe Coupee	115,421	103,226	216,583	193,699	169,953	151,995	25,820	23,092
St. Bernard	270,257	548,349	507,126	1,028,955	397,941	807,418	60,458	122,669
St. Charles	152,404	233,245	285,979	437,674	224,407	343,442	34,094	52,178
St. James	101,752	102,171	190,934	191,721	149,825	150,443	22,763	22,856
St. John	122,436	175,717	229,746	329,725	180,281	258,735	27,390	39,309
St. Landry	421,163	378,017	790,296	709,334	620,143	556,613	94,217	84,565
St. Martin	167,696	175,795	314,675	329,872	246,925	258,849	37,515	39,326
St. Mary	310,767	396,700	583,142	744,391	457,590	584,122	69,520	88,744
St. Tammany	335,242	763,204	629,069	1,432,122	493,629	1,123,783	74,996	170,733
Tangipahoa	348,408	372,063	653,774	698,161	513,015	547,845	77,941	83,233
Terrebonne	389,853	482,932	731,544	906,203	574,041	711,095	87,213	108,035
Vermilion	227,764	227,392	427,390	426,693	335,372	334,825	50,952	50,869
W. Baton Rouge	86,400	103,399	162,126	194,025	127,220	152,251	19,328	23,131
Coastal	11,530	14,277,172	24,362,149	30,164,552	19,116,918	23,670,049	2,904,385	3,596,130
Noncoastal	5,572	5,470,120	11,773,810	11,557,170	9,238,879	9,068,883	1,403,639	1,377,812
State	17,103,497	19,747,292	36,135,959	41,721,722	28,355,797	32,738,932	4,308,024	4,973,942

*Summer period is high quarter for all activities except hunting.

Source: Roger Burford and Sylvia G. Murzyn, Population Projections by Age, Race and Sex, for Louisiana and Its Parishes 1970-1985. (Occasional Paper No. 10), Div. of Research, College of Business Administration, Louisiana State University, Baton Rouge, June, 1972; State of Louisiana Outdoor Recreation Plan, State Parks and Recreation Commission, June, 1971.

source advantages of the coast areas account for the patterns observed. This is especially true for water activities other than fishing.

Since it is predicted that the state's population increase over the next 15 years will be primarily in the coastal parishes, one can expect greater demands on existing recreation facilities there and a need for the creation of new ones. For this reason, projections of future recreation needs were attempted.

The future demand for outdoor recreation was calculated by multiplying population projections for parishes in 1985 (Table 5) by current recreation participation rates as determined in the outdoor recreation survey made by the Louisiana State Parks and Recreation Commission in 1968.[12] Since these data are 5 years old, the projections are probably a conservative estimate of outdoor recreation needs for 1985. An overall increase in Louisiana recreation participation rates to conform to national recreation patterns can be expected.

The projection trendline calculated for hunting, fishing, crabbing, and crawfishing, in terms of user days, for the period from 1970 to 1985 is shown in Figure 19. An upward trend is projected for the coastal zone, while a decline is projected for the noncoastal area in terms of user days.

Projections for water activities such as motor boating, water skiing, canoeing, and sailing also show an expected steady increase in user days in the coastal zone as contrasted to the noncoastal area (Table 15). Projections for camping, both tent and trailer, follow a similar pattern.

Projections for swimming, which include pool and beach and water skiing (Figure 20), show a dramatic increase in terms of user days from 1970 to 1985 for the coastal zone. This jump in participation apparently will not be experienced in the remainder of the state.

These projections of user days for various forms of outdoor recreation point to a serious need for program development in Louisiana. This growing need is basically a function of growing population. Since population growth in Louisiana is taking place mainly in the coastal parishes, the need for recreation planning seems to be more critical there.

In concluding this section, certain observations are in order. The first is that Louisiana faces a great and inescapable challenge to develop more outdoor recreation facilities. Part of the challenge is to plan this development in such a way as to ensure the protection of both natural beauty and environmental quality. The current use of overcrowded swimming pools and undeveloped streams, lakes, reservoirs, and beaches results in conditions which discourage proper utilization of available resources.[13]

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[12] Louisiana State Parks and Recreation Commission, Comprehensive Outdoor Recreation Plan, 1970-1975, June, 1971, p. 4.4.

[13] For a more extensive discussion of recreation activities in Louisiana and recommendations for actions by state government, see *Louisiana Wetlands Prospectus,* Louisiana Advisory Commission on Coastal and Marine Resources, September 1973, Chapter 6, Section 3, pp. VI-19 to VI-45.

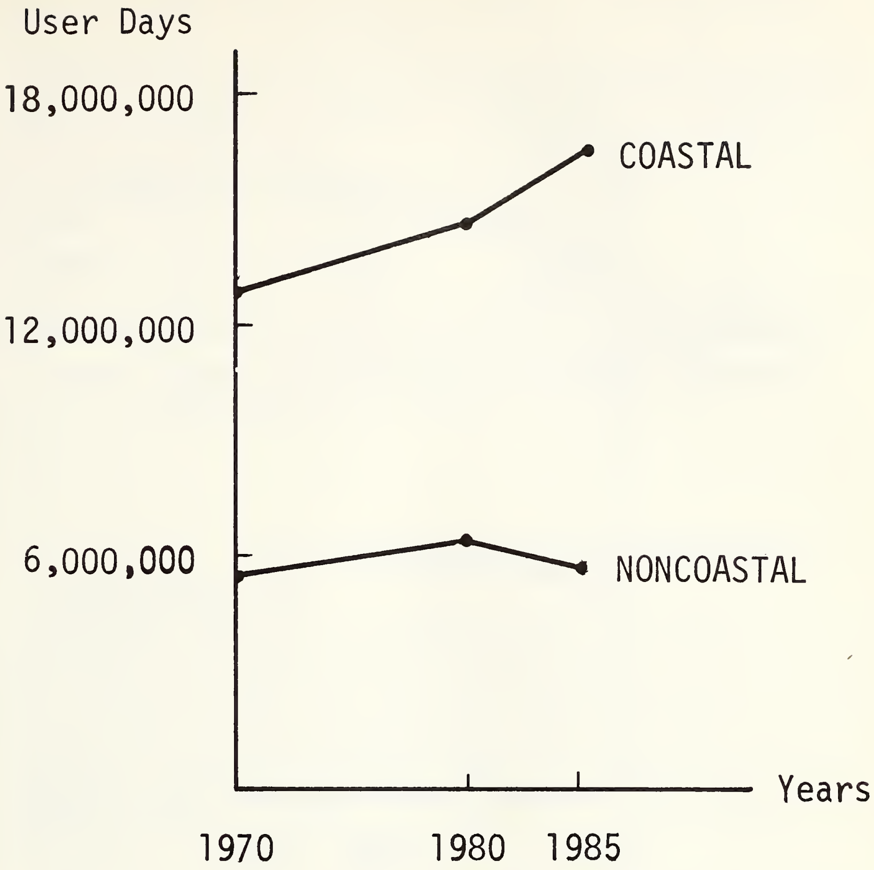

Figure 19.—Resource-based recreation projections for Louisiana hunting, fishing, crabbing, and crawfishing in the coastal and noncoastal areas from 1970 to 1985.

Source: *State of Louisiana Outdoor Recreation Plan,* State Parks and Recreation Commission, June, 1971.

In addition, many areas suitable for recreation activities are either inaccessible or lack such facilities as boat launching ramps, rental boats, or fishing piers. The amount of water presently suitable for recreation but inaccessible in the two areas of the state is delineated in Table 16.

All in all, outdoor recreation activity appears to be one of the great opportunities for those charged with developing the natural resources of the state and its coastal zone.

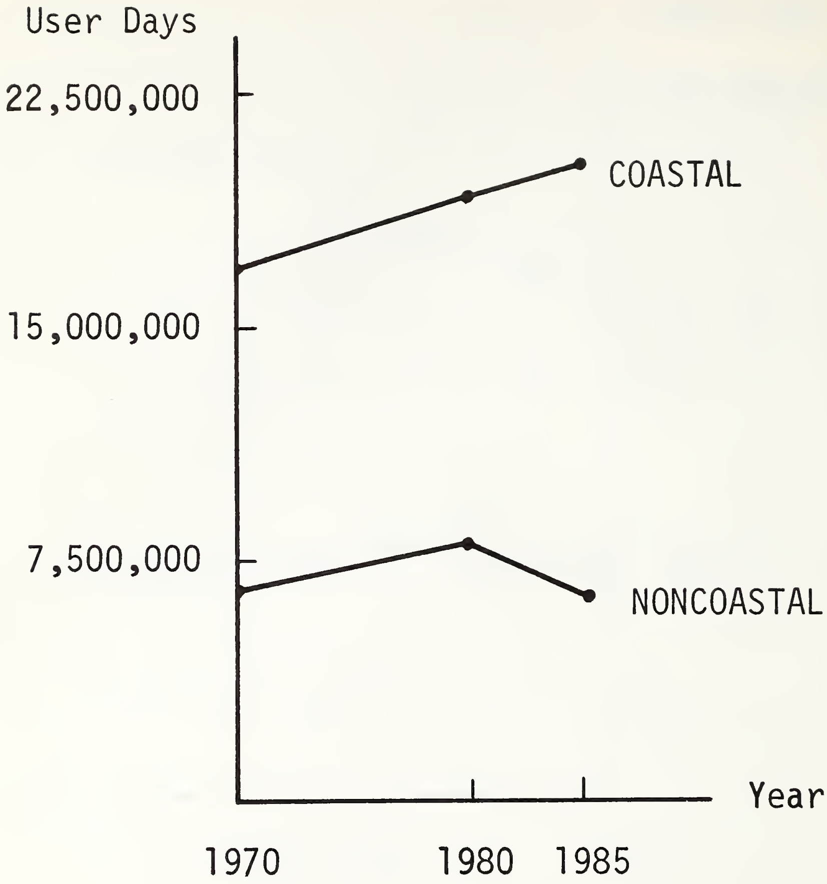

Figure 20.—Recreation projections for number of user days of swimming (pool and beach) in the coastal and noncoastal areas of Louisiana from 1970 to 1985.

Source: Table 11, *State of Louisiana Outdoor Recreation Plan,* State Parks and Recreation Commission, June, 1971.

TABLE 16.-Accessible and Inaccessible Water Acreage in Louisiana Suitable for Recreaion

Region	Suitable Water	Accessible Water	Inaccessible Suitable Water	Percent Suitable Water Now Inaccessible
Coastal	1,296,380	82,836	1,213,544	93.6
Noncoastal	317,395	91,572	225,823	71.1
State	1,613,775	174,408	1,439,367	89.2

Source: Louisiana State Parks and Recreation Commission, Comprehensive Outdoor Recreation Plan, 1970-75, June, 1971, p. 4.4.

Summary and Conclusions

Louisiana's coastal zone, in comparison with the noncoastal area, is densely populated, has more major population centers, and has a larger percentage of the population living in urban areas. Population growth rates are higher in the coastal zone than in the noncoastal area, which is a reflection of more births than deaths rather than high in-migration. The fact that the population in the coastal zone is younger will no doubt affect birth rates in future years. Culturally the coastal zone is predominantly French-Catholic while the noncoastal area is mainly non-French and Protestant.

The economy of Louisiana has a broad base. Mining, contract construction, and farming and farm-related industries produce a large percentage of the state's gross product. Although the number of acres of land in farming and the number of farms in the state have declined, over one-third of the land area in the coastal zone is still in agricultural production. The number of farms has declined in both the coastal and noncoastal areas, while the average farm size in both regions has increased. Commercial fishing in the coastal zone provides many jobs and is an economic base not found in the remainder of the state. Mineral production, which provides a large share of the gross state product, is also primarily located in the coastal zone.

It is logical to expect the demand for improved and additional recreation facilities in Louisiana to increase during the next 20 years because of the growing population. Projections of user days for swimming, hunting and fishing, camping, and water-related activities such as boating and skiing, indicate that demand for these activities in the coastal zone will rise rapidly over the next 10 years while the noncoastal areas will experience a decline in these types of recreation. Fishing and hunting are more popular in Louisiana than in the rest of the nation and considerably more than half of the resident fishing licenses sold in Louisiana during 1970 were sold in the coastal zone. The coastal zone also leads the rest of Louisiana in the number of hunting licenses sold, other than big game licenses.

Future trends are implicit in the patterns now in evidence in Louisiana. In particular, the coastal zone is going to continue to be the area of greater population growth, as it has been in the past. This highlights the central dilemma of planning for the increasingly intense confrontation between man and a rather fragile coastal zone ecosystem, a confrontation evident in population growth trends, urbanization, industrialization, and increasing demands for recreation resources. Equally important from the perspective of wetland management is the fact that the coastal zone overlaps closely the area of French-Catholic Louisiana. Educational programs designed to make the whole state aware of land-use problems must be designed with this socio-cultural dichotomy in mind. The political ramifications of this cultural characteristic are also important.

This information is presented in the hope that it will be useful to planners concerned with the development of the coastal zone and the state.

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The Response of an Oat-Ryegrass Mixture to Applied Nitrogen, Phosphorus and Potassium

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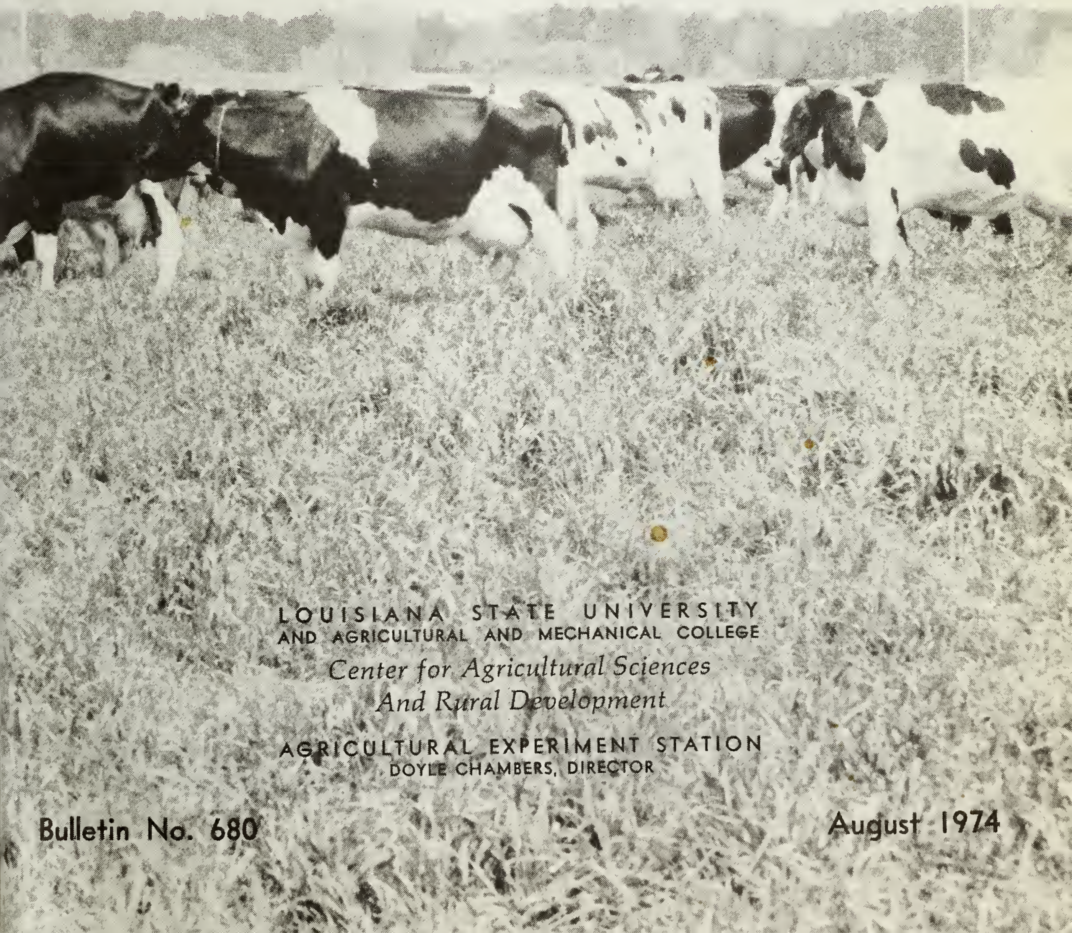

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The Response of an Oat-Ryegrass Mixture to Applied Nitrogen, Phosphorus and Potassium

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INTRODUCTION AND OBJECTIVES

Considerable research has been reported regarding the response of forages to fertilization. In most of this work only one major plant nutrient was applied and only yield was measured. Preliminary work of this nature was necessary and contributed significantly to basic and general fertilizer recommendations for forage crops. This was particularly true following World War II with the rapid increase in the use of fertilizer on pastures.

As knowledge of forage yield response to fertilizers accumulated, researchers began to consider methods of altering and improving forage quality and growth distribution. Considerable effort in recent years has been directed to the measurement of forage "quality" for animal consumption. Increasing cost and less profit in grassland farming place a premium on forage that is high in quality and yield. Uniform forage yield distribution throughout the season is of extreme importance to a successful grazing program. Thus, the evaluation of only total yield for the season may be misleading as to the value of a forage in a grazing program.

Prior research conducted at the Southeast Louisiana Dairy and Pasture Experiment Station, Franklinton, Louisiana, has shown significant yield responses of forage crops to applied nitrogen, phosphorus, and potassium. In most cases, one or two of the nutrients were held constant at what was considered an adequate level and the other nutrient(s) was applied at various rates.

Ryegrass in pure stands produces a higher total dry forage yield than oats alone. However, an oat-ryegrass combination was used in this study because the oats provide forage for grazing 20 to 30 days earlier in the fall than ryegrass, and ryegrass provides grazing about 30 days longer in the spring than oats. Thus the oat-ryegrass mixture has a longer growing season for grazing than either oats or ryegrass alone. Also, a more uniform distribution of growth is obtained throughout the season with a mixture than with either species alone.

An experiment with varying rates of applied nitrogen, phosphorus, and potassium to measure effects on both yield and quality of an oat-ryegrass mixture was initiated in 1966. The selection of this mixture was based on research which had shown that it provided a longer growing season and a more uniform distribution of growth than any single species or other cereal-ryegrass combination. Approximately six months of grazing were provided by this mixture.

---

[1] Associate Professor, former Professor, Associate Professor, Research Associate, Southeast Louisiana Dairy and Pasture Experiment Station, Franklinton, Louisiana; Professor, Department of Experimental Statistics, Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana, respectively.

The objectives of this investigation included:

(1) Determination of the response to various rates and ratios of N, P, and K as measured by total pounds of dry forage, crude protein, and *in vitro* digestible dry matter produced per acre.

(2) Effects of rates and ratios of N, P, and K on the quality of the forage as measured by percent crude protein, structural carbohydrates, *in vitro* digestible dry matter, phosphorus, potassium, calcium, and magnesium.

(3) To characterize yield and quality measurements over the growing season, by use of regression equations.

REVIEW OF LITERATURE

The effects of various rates and combinations of the three major plant nutrient elements on yield, chemical composition, and quality of forage crops have been studied in detail by several investigators. Fewer studies have been made of the combined effects of nitrogen, phosphorus, and potassium than of the effects of one or any two of the three nutrients. In general, forage yield, chemical composition, and quality will vary greatly due to species, fertility status, stage of maturity, and climatic conditions.

Pratt (*17*)[2] summarized data in a study of digestibility and utilization of nutrients by dairy cows from fertilized and nonfertilized bluegrass pastures. The conclusions were that for practical purposes, herbage from nonfertilized bluegrass met the animal needs for milk production as well as did that from a fertilized pasture, provided enough herbage was available to supply the additional energy required to gather the herbage on the poorer sod. It was pointed out that the increased yield due to fertilization justified a fertilization program.

Brown and Hollowell (*7*) reported that the use of nitrogen fertilizer, regardless of the carrier, frequently resulted in a slight increase in the phosphorus content of the forage but appreciably reduced the calcium content.

McCalla (*11*), from his work in the anion-cation balance in wheat, stated that the ion balance was always decidedly in favor of anions, regardless of the nutrition of the plant. Results demonstrated that the effect of limiting a nutrient increased the absorption of another ion of the same sign, or decreased the total absorption of ions of the opposite sign. Limiting nitrogen caused an increased phosphorus and sulfur absorption. Limiting potassium caused an increased calcium and magnesium absorption.

Peech and Bradfield (*16*) stated that the addition of lime containing neutral salts, or strong acids, may increase, decrease, or have no effect on the concentration of potassium in the soil solution, depending on the initial degree of base saturation of the soil. In the absence of neutral salts, adding lime liberated adsorbed potassium even when an insufficient amount of lime was added to neutralize all of the exchangeable hydrogen ions.

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[2] Italic numbers in parentheses refer to list in References, page 62.

A summary of data by Albrecht (*2*) showed that, with the addition of lime and phosphorus as a soil treatment, there was a 21 percent increase in yield, a 30 percent increase in protein in the forage, and a 50 percent increase in animal gain per unit weight of forage fed. He concluded that yield and chemical analysis alone were insufficient to measure the value of all the beneficial effects of fertilizer treatments. He had concluded earlier (*1*) that nutritional differences were greater in seasons unfavorable for plant growth. The protein and mineral contents of the hays used did not differ as widely as their efficiency in producing animal gains. This would indicate that soil treatments bring about other compositional changes not commonly measured. He presented evidence that additions of fertilizer or lime to an extent that would cause unbalanced nutrient conditions in the soil actually resulted in a crop of lower efficiency than where no nutrient addition was made.

Maynard (*10*) reported that crude protein in excess of 16 to 18 percent of the dry matter of the ration of herbivorous animals had no advantage for any purpose. Deleterious effects occurred when the phosphorus content of the dry matter was 0.12 percent or less. Maximum demands such as animal growth and lactation may require as much as 0.30 percent phosphorus in the forage. The calcium content should be 0.35 percent on a dry matter basis when grass hay is the only source of calcium.

Patrick (*15*) demonstrated with Olivier silt loam soil that the level of calcium and magnesium in the plant was dependent on the potassium concentration in the soil, as well as the concentration of calcium and magnesium in the soil.

Morrison (*12*) stated that good pastures, alone, will provide cows with sufficient nutrients for body maintenance and the daily production of 10 to 20 pounds of milk.

Data by Hodgson and Sweetman (*9*) indicate a lactating dairy cow needs 0.045 pound of digestible protein, 0.32 pound of total digestible nutrients, 1 gram of calcium, and 0.7 gram of phosphorus per pound of 4 percent fat-corrected milk. With pastures of high feeding values, high milk producers cannot ingest enough total nutrients to meet their needs, because the forage is succulent and bulky. Under good conditions, these animals will consume about 30 pounds of dry matter daily, enough for maintenance and production of 32 pounds of milk per day.

Russell (*19*) explained that when nitrogen fertilizer stimulates crop growth, the nitrogen content of the fertilized crop, expressed as a percentage of its dry or fresh weight, will often decrease, although the total uptake of nitrogen per acre will increase. This is because the extra dry matter which the added nitrogen stimulated the plant to produce has a lower nitrogen content than that produced by a nitrogen-starved plant.

Brouwer (*6*) stated the Ca/P ratio is of considerable importance in the diet of ruminants and that diseases resembling rickets develop if this ratio is too high or too low. Ratios of K/Na, K/Ca, Na/Ca, Ca/P, Mg/P, and Ca/Mg, as well as probably other ratios, are important in animal nutrition and health. An important point of consideration is that a change in the ratio of any two elements cannot occur alone. Forages that induce grass tetany are characterized by high K values and low Ca and Mg values.

Data obtained from the National Research Council (*13*) indicated the following ranges in mineral content are considered adequate in forage for a beef cow with a calf at her side (percent, on a dry matter basis): nitrogen 2.5 to 3.0, phosphorus 0.26 to 0.32, potassium 1.8 to 2.1, calcium 0.22 to 0.25, and magnesium 0.16 to 0.20.

EXPERIMENTAL PROCEDURE

The experiment was conducted on a Lexington silt loam soil at the Southeast Louisiana Dairy and Pasture Experiment Station, Franklinton, Louisiana. It commenced in the fall of 1966 and continued through the 1970-71 season. Prior history of the experimental site included a six-year study with nitrogen rates on cool season annual grasses, in which phosphorus and potassium were applied uniformly at 140 pounds per acre each of P_2O_5 and K_2O, respectively. This was followed by two years of cool season varietal testing which received annual applications of 200 pounds of nitrogen and 100 pounds each of phosphorus and potassium expressed as P_2O_5 and K_2O, respectively. Two tons of dolomitic limestone per acre were applied and incorporated into the soil on August 1, 1966. Soil analyses, prior to the initiation of the experiment, showed the soil contained 28 p.p.m. extractable P, 45 p.p.m. extractable K, 720 p.p.m. extractable Ca, and 187 p.p.m. extractable Mg, and had a 5.45 pH.

The experimental design was a randomized complete block with four replications. Three levels of nitrogen (200, 300, and 400 pounds per acre), phosphorus (100, 200, and 300 pounds expressed as P_2O_5 per acre), and potassium (100, 200, and 300 pounds expressed as K_2O per acre) were applied annually in a factorial arrangement of treatments. For base line information, nine additional treatments were included in which one or more of the plant nutrients were not applied.

The 36 treatments are summarized in the table on Page 7.

The sources of fertilizer material used were ammonium nitrate (33.5 percent N), triple superphosphate (46 percent P_2O_5), and muriate of potash (62 percent K_2O). These materials were weighed and applied by hand. All the P and K and one-half the N were applied broadcast and disced in prior to planting. Of the remaining N, one-half was applied in late December and one-half in mid-March.

The overall plot size was 10' x 21', the fertilized area was 8' x 20', and the harvested area was 4' x 16'. The planting dates varied from Sept. 15 to Sept. 30. Moregrain oats (*Avena sativa*) and Gulf ryegrass (*Lolium multiflorum*) were planted at rates of 112 pounds drilled and 30 pounds broadcast per acre, respectively.

The clipping schedule for the first four years was based on the height of the forage. Plants were clipped to a 4-inch stubble when the forage averaged 12 to 14 inches high. Beginning in the fall, 1970, plants were clipped to a 3-inch stubble on the first and fifteenth of each month. Clippings for each season numbered 6, 6, 7, 6, and 10, respectively, beginning with the 1966-67 season.

The forage was cut with a sickle bar mower and collected in an attached metal tray. Green weights were recorded and sub-samples of the forage were dried in a forced-air, thermostatically controlled dryer. Drying temperature did not exceed 135° F. Forage samples were ground in a Wiley mill with a 1-mm screen for laboratory determinations.

Determinations of crude protein, P, K, Ca, and Mg of the forage were made according to A.O.A.C. procedures (*5*). Cell wall constituents, acid detergent fiber, and digestible dry matter were determined by the Van Soest procedure (*22*). The *in vitro* digestible dry matter procedure was modified by the addition of glucose and urea to the buffer solution to supply 0.05 and 0.25 percent of these nutrients to each fermentation tube, respectively. All data are reported on a dry matter basis.

Statistical analysis of the data was conducted according to Snedecor (*20*). The data from all years were pooled over replications, and an analysis of variance was conducted for each variable using years as replications. An analysis of variance was conducted for the 3 x 3 x 3 factorial arrangement of treatments and all 36 treatments. All data were recorded by clipping date. A regression analysis of each variable on clipping date, recorded as number of days since the base date of September 1, was conducted where the linear, quadratic, cubic, and quartic terms for clipping date were included. Regression analyses were conducted for each level of N, P, and K in the factorial arrangement, specific combinations of N, P, and K, and the control treatment, where no fertilizer (no N, P, or K) was applied. Coefficients of variation and all possible correlation coefficients were calculated.

Pounds plant nutrients per acre applied annually				
N		P_2O_5		K_2O
200		100		100
300	x	200	x	200
400		300		300
0		0		0
200		0		0
0		200		0
0		0		200
200		200		0
200		0		200
0		200		200
300		0		0
400		0		0

RESULTS AND DISCUSSION

Several terms used and discussed are abbreviated for simplicity and the conserving of space. They are as follows:

N —Pounds per acre of applied nitrogen.
P_2O_5 —Pounds per acre of applied phosphorus (P), expressed as P_2O_5.
K_2O —Pounds per acre of applied potassium (K), expressed as K_2O.
Protein —Percent crude protein (percent total N x 6.25) in the forage.
CWC —Percent cell wall constituents in the forage.
ADF —Percent acid detergent fiber in the forage.
DDM —Percent *in vitro* digestible dry matter in the forage.
P —Percent phosphorus in the forage.
K —Percent potassium in the forage.
Ca —Percent calcium in the forage.
Mg —Percent magnesium in the forage.

A. Pounds Dry Forage Yield Per Acre

1. Nitrogen

Total forage yield responded significantly to applied N (Table 1). Total yield increased by nearly 700 pounds and 500 pounds per acre with the 300- and 400-pound levels of N, respectively, over the 200-pound rate. The increase between the 300- and 400-pound rates was less than that between the 200- and 300-pound rates, indicating that total yield as a response to applied N was beginning to peak.

Levels of N had a significant effect on the yield distribution over the growing season, although the confidence intervals are not shown (Figure 1). However, there were no real yield differences between levels of N until early March. Thus, a total of 150 pounds of N, with 100 pounds applied at planting and 50 pounds in mid-December, was sufficient to provide maximum growth until early March. Differences in response of yield to N were evident beginning in early March. Statistical yield differences did not occur between the 300- and 400-pound levels of N until mid-April. Consequently, season, or when the forage was harvested during the season, had an interacting dominant effect on yield among N levels. This is verified by the regression equation R^2 values in Table 18 (Appendix). The variation obtained in yield distribution response to the 300-pound level of N from early November to early March was not expected to occur.

Yield data of all individual treatments are shown in Table 2. Plots that did not receive any fertilizer produced 3,836 pounds of forage per acre, whereas a total of 7,186 pounds were produced with a 200-100-100 application. Total forage yield of the nonfertilized oat-ryegrass mixture was similar to that of other nonfertilized forage crops grown at this location. However, the growth curve of the nonfertilized oat-ryegrass forage was quite similar to that of forage with complete fertilizer, but the yield was much lower throughout the season (Figure 1).

Table 1. Mean effects of applied N, P, and K on pounds dry forage per acre of an oat-ryegrass mixture, five-year average

Lbs/a		Lbs/a P_2O_5		
N	100	200	300	Av
200	7561^{a1}	7710^{a2}	7754^{a3}	7674^{a}
300	8345^{b1}	8478^{b2}	8498^{b3}	8440^{b}
400	8586^{c1}	9046^{c2}	9194^{c3}	8942^{c}
Av	8172^{1}	8411^{2}	8481^{3}	8355

Lbs/a		Lbs/a K_2O		
N	100	200	300	Av
200	7501^{a1}	7732^{a2}	7790^{a3}	7674^{a}
300	8054^{b1}	8610^{b2}	8682^{b3}	8448^{b}
400	8449^{c1}	9053^{c2}	9324^{c3}	8942^{c}
Av	8001^{1}	8465^{2}	8599^{3}	8355

Lbs/a		Lbs/a K_2O		
P_2O_5	100	200	300	Av
100	7698^{a1}	8420^{a2}	8397^{a2}	8172^{a}
200	8134^{b1}	8464^{b2}	8636^{b3}	8411^{b}
300	8172^{b1}	8510^{c2}	8762^{c3}	8481^{c}
Av	8001^{1}	8465^{2}	8598^{3}	8355

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P < .05$.

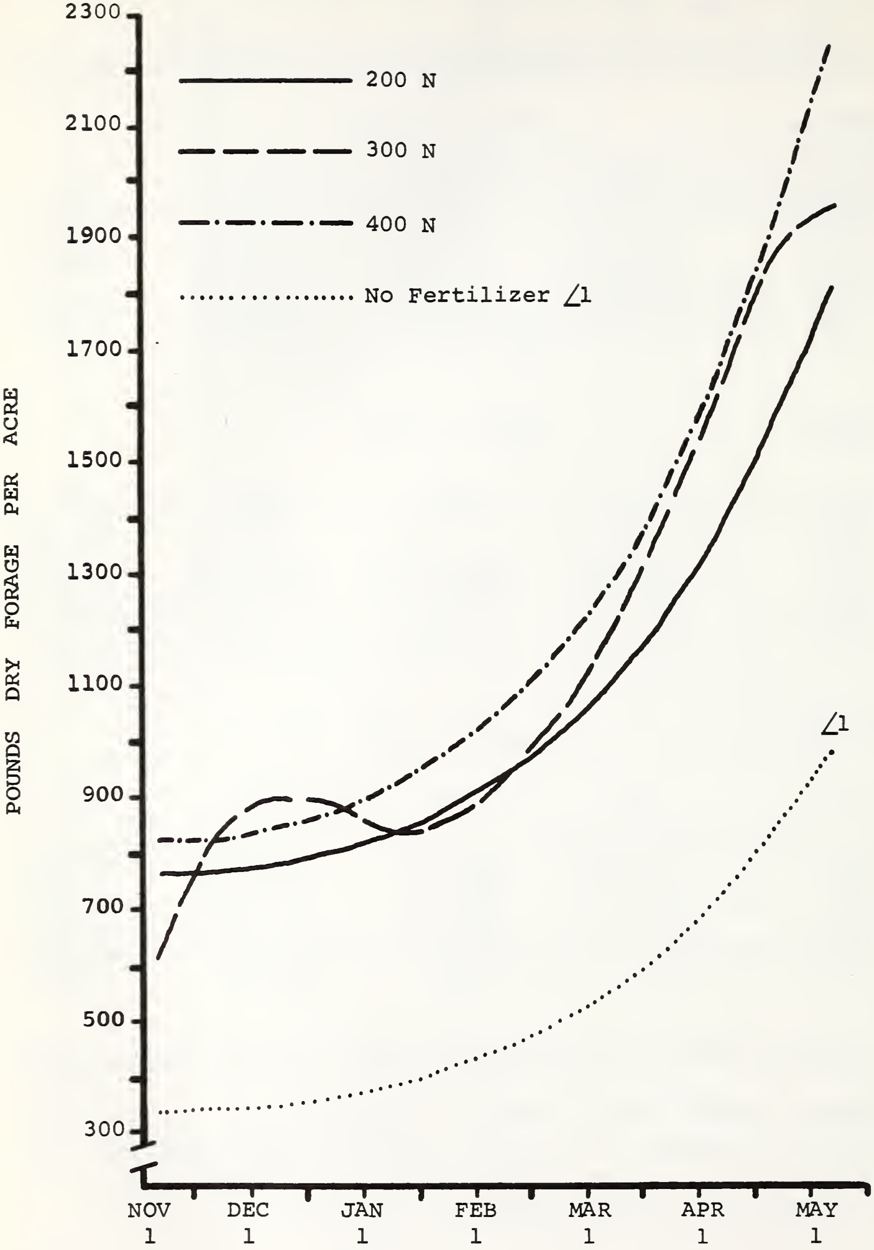

Fig. 1. Mean effects of lbs/a of applied N averaged over 100, 200, and 300 lbs/a of applied P_2O_5 and K_2O on the forage yield distribution of an oat-ryegrass mixture. Average of seven clippings per year over five years.
∠1 The no fertilizer line is included to provide base line information only.

2. Phosphorus

Increasing the applied P_2O_5 from 100 to 300 pounds per acre resulted in significant yield increases (Table 1). The increases were only 239 pounds of forage at the 200-pound P_2O_5 rate over the 100-pound rate, and 70 pounds of forage at the 300-pound rate over 200 pounds P_2O_5 per acre. However, the importance of these yield increases is questionable, economically, and other factors relative to the quality of the forage and soil fertility status should be considered.

The yield differences due to levels of applied P_2O_5 occurred mainly from mid-November to early March (Figure 2). There was no yield distribution advantage to the 300-pound P_2O_5 rate over the 200-pound

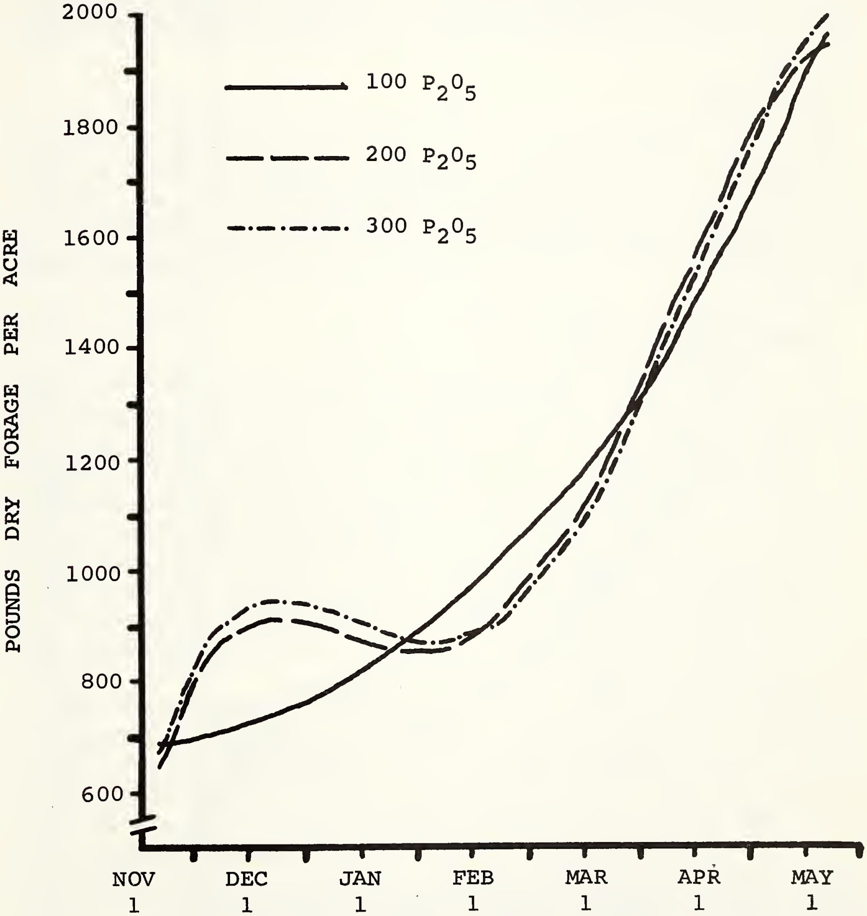

Fig. 2. Mean effects of lbs/a of applied P_2O_5 averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied K_2O on the forage yield distribution of an oat-ryegrass mixture. Average of seven clippings per year over five years.

rate. A significant interaction was obtained between years and P_2O_5 levels (Table 16). Thus, variations in air temperature (Appendix, Figures 15-18) and soil moisture (Appendix, Tables 19-22) during the growing season affected yield response to P_2O_5 levels differently. The percent P in the forage increased significantly with increased levels of P_2O_5 (Table 11, Figure 11). The period of time that P content was highest in the forage corresponded with the period that yields for the 200- and 300-pound rates were lower (Figure 2) than for the 100-pound rate. This may indicate that the high P uptake by the plants had a detrimental effect on the phosphatic energy-transfer enzyme system and metabolic processes. If this occurred, excessive P in the plants would lower the growth rate during the colder part of the season, with plants regaining a higher P utilization and growth rate in the spring when growing conditions improved.

3. Potassium

There was a significant increase in yield due to increased applications of K_2O (Table 1). The increase was greater between the 100- and 200-pound rates than between the 200- and 300-pound rates, 464 and 134 pounds dry forage per acre, respectively. The differences occurred from mid-November to early January, and from mid-March through April (Figure 3).

4. Other Relationships

Yield responses to all individual N-P_2O_5-K_2O combinations are shown in Table 2. A treatment combination represents pounds of N-P_2O_5-K_2O applied per acre. Yields of 14 of the 36 combinations were significantly different. Total yield, as an average of all treatment combinations, differed significantly among years. Yield responses throughout the season to four individual treatment combinations are illustrated in Figure 4. Yield response of the 300-200-200 did not differ from that of the 400-200-200 until mid-February. Data in Table 2 indicate that at the 200-pound level of N a 2-1-2 ratio, at the 300-pound level of N a 3-2-2 ratio, and at the 400-pound level of N a 4-2-3 ratio generally resulted in the highest yields.

Comparisons of yield data of individual treatments in Table 2 demonstrate the need for N, P, and K to be included in a fertilizer program for an oat-ryegrass mixture on soil similar to that at this location. The application of 0-0-200 did not increase yield over that of the 0-0-0. However, the application of 0-200-0 did significantly increase the yield by 258 pounds of dry forage per acre over that of the 0-0-0. The application of 200-0-0 produced 2,038 pounds more forage than did the 0-0-0 combination, but 1,312 pounds less than the 200-100-100 combination. Both the 200-200-0 and the 200-0-200 increased yield by 873 pounds over the yield from 200-0-0. The 200-100-100 resulted in 439 pounds more forage than either the 200-200-0 or the 200-0-200 combination. Thus, a greater response occurred by the application of N alone as compared with P or K alone, with the response of P or K alone being similar. But the omission of any one of the three plant nutrients reduced significantly the response to those nutrients that were applied as compared with the response when all three were applied.

There were no significant interactions among applied N, P, and K on yield (Table 16). There was a significant year effect on yield. This was primarily due to variation in the amount and distribution of rainfall and temperature fluctuations among years. Temperature was below the minimum considered adequate for forage growth about 10 days each year, and these periods varied from mid-December to early February.

Correlation coefficients between yield and the other measurements are shown in Table 17. Protein, P, and K content in the forage were negatively correlated with yield, whereas Ca had a low positive correlation with yield. This indicates the ability the plants have to take up, translocate, and utilize N, P, and K for additional growth.

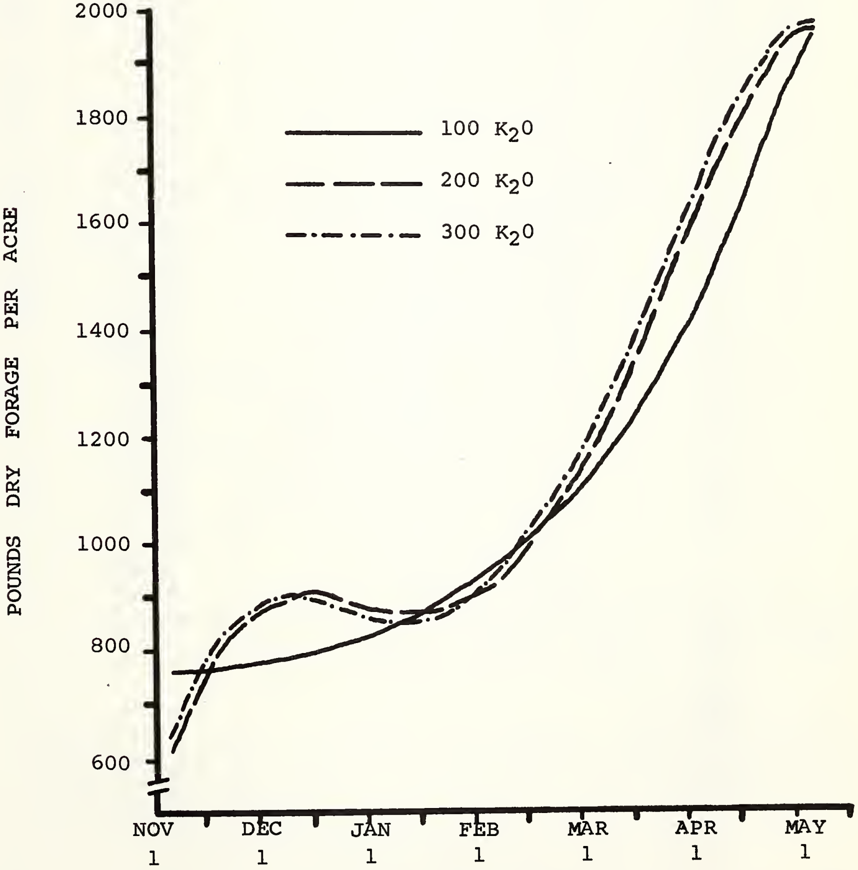

Fig. 3. Mean effects of lbs/a of applied K_2O averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied P_2O_5 on the forage yield distribution of an oat-ryegrass mixture. Average of seven clippings per year over five years.

Table 2. Effects of applied N, P, and K on pounds dry forage per acre of an oat-ryegrass mixture, five-year average

Pounds per acre			Dry forage
N	P_2O_5	K_2O	
200	100	100	7186^{f}
200	200	100	7679^{g}
200	300	100	7643^{g}
200	100	200	7919^{h}
200	200	200	7590^{g}
200	300	200	7689^{g}
200	100	300	7578^{g}
200	200	300	7862^{h}
200	300	300	7929^{hi}
300	100	100	8004^{i}
300	200	100	8121^{i}
300	300	100	8036^{i}
300	100	200	8496^{j}
300	200	200	8733^{k}
300	300	200	8599^{j}
300	100	300	8536^{j}
300	200	300	8580^{j}
300	300	300	8859^{k}
400	100	100	7904^{h}
400	200	100	8601^{j}
400	300	100	8843^{k}
400	100	200	8846^{k}
400	200	200	9070^{l}
400	300	200	9242^{m}
400	100	300	9008^{l}
400	200	300	9465^{n}
400	300	300	9498^{n}
0	0	0	3836^{a}
200	0	0	5874^{c}
200	200	0	6717^{e}
200	0	200	6777^{e}
0	200	0	4094^{b}
0	0	200	3880^{a}
0	200	200	4209^{b}
300	0	0	6380^{d}
400	0	0	5978^{c}
Year Av			
1966-67			9100^{e}
1967-68			7772^{d}
1968-69			6653^{a}
1969-70			7562^{c}
1970-71			6866^{b}

Values with same letter superscript not significantly different at $P\underline{/}.05$. Superscripts pertaining to data of fertilizer treatments are not related to the superscripts in the year average portion of the table.

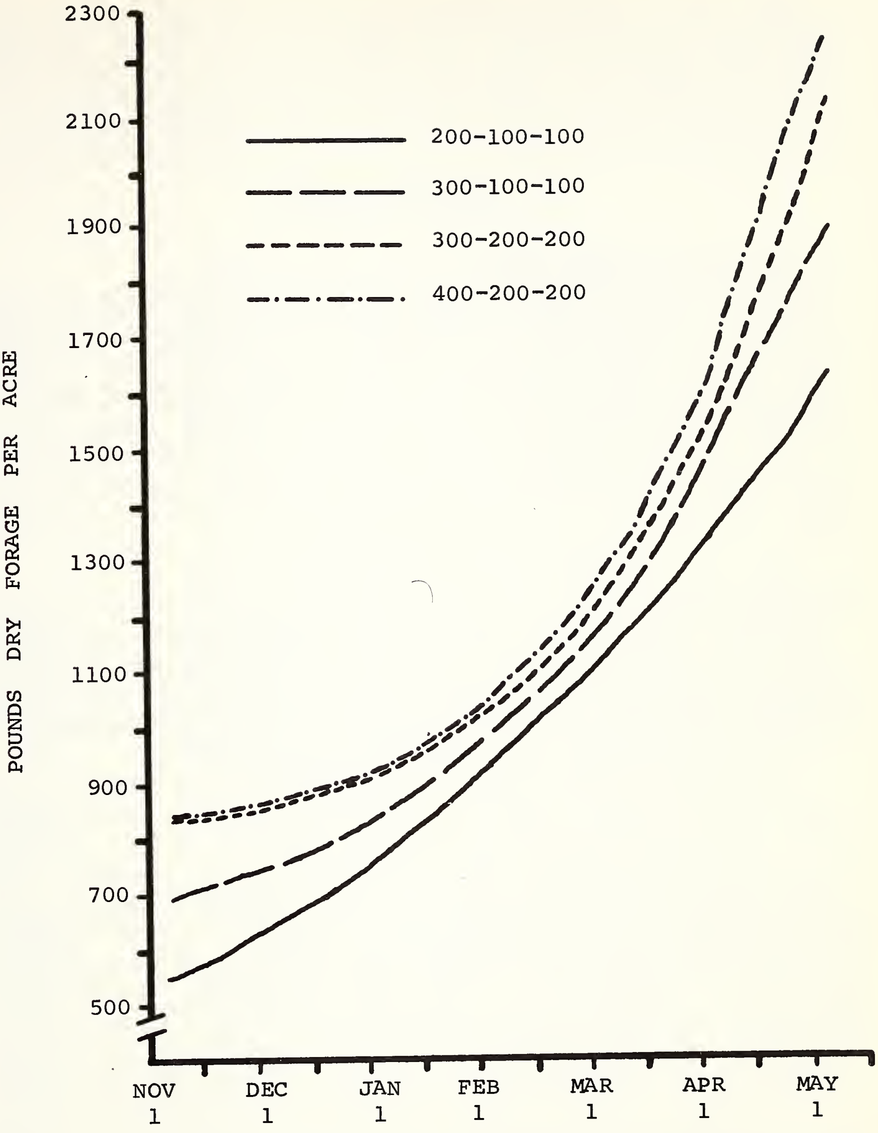

Fig. 4. Mean effects of lbs/a of specific combinations of applied N, P_2O_5, and K_2O on the forage yield distribution of an oat-ryegrass mixture. Average of seven clippings per year over five years.

The CWC and ADF were positively correlated with yield. Both increased rapidly in the spring as yield and cell differentiation increased. The DDM was negatively correlated with yield, which reflects changes in cell content, cell differentiation and maturation, and plant morphology that occur with increased yield in the latter part of the growing season.

B. Forage Quality

1. Percent Crude Protein

The percent crude protein in forage has long been recognized as an indicator of forage quality for ruminants. It is calculated by percentage total N in the forage multiplied by 6.25. Protein digestibility of forage has been positively correlated with percent protein of the forage. It is generally accepted that the protein digestibility of the forage used in this study is relatively high compared with that of warm season perennial grasses. Crude protein content in forage of 15.6 to 18.7 percent on a dry matter basis has been considered adequate for a beef cow with a calf at her side.

(a) Nitrogen

Average crude protein content in the forage increased significantly with each increase of applied N (Table 3). The increases were 1.4 and 1.8 percent, respectively, with 300 and 400 pounds of N over 200 pounds. However, the protein in the forage at the 200-pound rate averaged 3.5 percent higher than that in the nonfertilized forage (Table 5).

The protein of the forage throughout the season as affected by applied N is illustrated in Figure 5. Protein at all levels of N was highest in November and decreased gradually until mid-March. There was only about a 2 percent difference due to level of N until mid-January. The largest difference in protein content due to applied N occurred in mid-March between the 200- and 300-pound levels of N. A rapid decline in protein began in mid-March and continued to the end of the season. The protein content at all levels of N was separated by only a 3 percent difference at the end of the season. The slight variations of protein content throughout the season, particularly in early November, January 1, mid-March, and late April reflect a N x clipping date interaction (Table 16). It should be pointed out that the forage was maintained in a vegetative stage throughout the season. More frequent clippings in the spring tended to delay maturation. It is obvious that some morphological change and cell maturation occurred. Botanically, the forage was predominantly ryegrass during the last month of the growing season. Generally, ryegrass remains vegetative about 30 days longer than oats. Although a shift in the botanical composition of the forage occurred, the latter part of the season had a greater effect on protein (Figure 5). This occurred even though one-fourth of the total N of each rate was applied in mid-March.

Protein in the nonfertilized forage was relatively high compared with that in the fertilized forage and decreased linearly until the end of the

Table 3. Means effects of applied N, P, and K on percent crude protein (dry matter basis) in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	23.4^{a1}	23.9^{a2}	23.6^{a12}	23.6^{a}
300	24.9^{b1}	25.1^{b1}	24.9^{b1}	25.0^{b}
400	26.9^{c1}	26.7^{c1}	26.9^{c1}	26.8^{c}
Av	25.1^{1}	25.2^{1}	25.1^{1}	25.2

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	24.2^{a2}	23.4^{a1}	23.2^{a1}	23.6^{a}
300	25.4^{b3}	25.0^{b2}	24.6^{b1}	25.0^{b}
400	27.3^{c2}	26.6^{c1}	26.6^{c1}	26.8^{c}
Av	25.6^{2}	25.0^{1}	24.8^{1}	25.2

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	25.3^{a2}	25.1^{a1}	24.9^{a1}	25.1^{a}
200	25.7^{ab2}	25.1^{a1}	24.9^{a1}	25.2^{a}
300	25.9^{b2}	24.9^{a1}	24.7^{a1}	25.1^{a}
Av	25.6^{2}	25.0^{1}	24.8^{1}	25.2

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P\angle.05$.

season (Figure 5). At the end of the season the protein of nonfertilized forage was less than 1 percent lower than that of the forage at the 200-pound level of N. The protein content of the forage at all levels of applied N was considered adequate for beef cows until early May. Protein content of the nonfertilized forage fell below this range in early April. These data also help explain why hay made in late spring, or as the plants approach maturity, tests uniformly low in protein regardless of the amount of N previously applied.

(b) Phosphorus

There was not a significant overall response of protein content in the forage to applied P_2O_5 (Table 3).

(c) Potassium

Applied K_2O had a significant effect on percent protein, in that protein content decreased as applied K_2O increased. A season average maximum difference of only 0.8 percent occurred among the applied rates (Table 3). This difference occurred in December and late February. Although statistically significant, it is doubtful that the differences are of importance economically. There was no interaction between levels of K_2O and clippings over years (Table 16).

(d) Correlations

Protein was positively correlated with P, K, Mg, and DDM (Table 17). The plant nutrients and protein are constituents of cell content. Protein is a highly digestible constituent of cell content. The extent to which ruminants can metabolize the minerals of the forage is uncertain. The highly

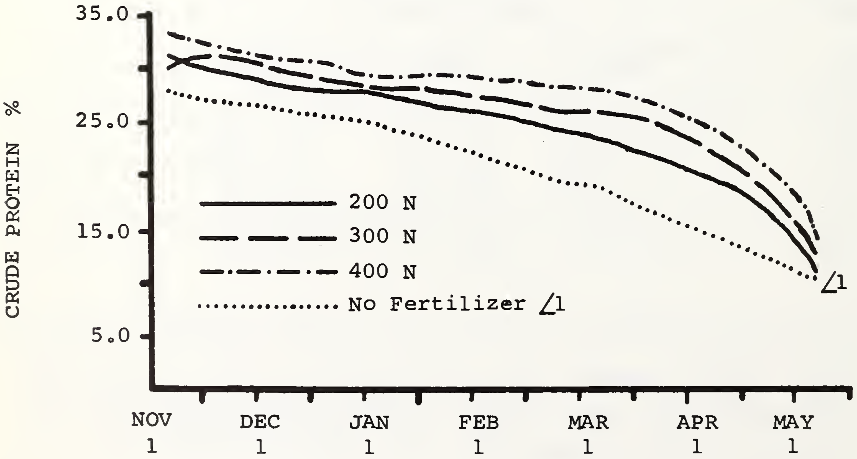

Fig. 5. Mean effects of lbs/a of applied N averaged over 100, 200, and 300 lbs/a of applied P_2O_5 and K_2O on crude protein content (dry matter basis) in forage of an oat-ryegrass mixture. Average of seven clippings per year over five years. ∠1 The no fertilizer line is included to provide base line information only.

significant negative correlation values of protein with CWC and ADF are indicative of the relationship between cell content and structural carbohydrates in these grasses. Cell content decreased as structural carbohydrates increased. This primarily occurred in the latter part of the growing season as cell differentiation and maturation progressed.

Protein synthesis in plants is dependent on P as a constituent of an energy-transfer mechanism in growth processes. Thus, as protein is increased or decreased, the level of P needed for this function varies accordingly. Potassium is mobile in the plant. It is involved in enzymatic processes and helps to maintain an ionic balance and cell pH. Calcium is laid down in the cell wall of plants and is immobilized. Magnesium is involved in the growth processes of the plant cell protoplasm.

The protein content indicates one of the reasons the forage used in this study is considered to be highly nutritious for ruminants when properly fertilized and managed to maintain it in a vegetative stage.

2. Pounds Crude Protein per Acre

Pounds of protein per acre may be used as a measure of quality on a quantitative basis and aids in an economic evaluation of the forage. The value per pound of protein may be somewhat arbitrary, but calculation of cost in producing pounds of protein per acre can be rather exact. Thus, one can make a relative economic assessment based on the cost of applied fertilizer and expected production.

(a) Nitrogen

Applied N had a significant effect on the pounds of protein produced per acre (Table 4). The season average increase was approximately 300 pounds per acre for each increase in N levels above the 200-pound rate. However, the total protein production was less than 700 pounds per acre with no applied fertilizer and less than 1,300 pounds when only N was applied, as compared with nearly 1,600 pounds per acre when a 200-100-100 combination was applied (Table 5). Production of protein from the fertilized plots increased in November, decreased from early December to late January, then increased until early April, and declined the remainder of the season (Figure 6). However, the pounds of protein produced in the nonfertilized forage was constant and did not fluctuate throughout the season. Differences in pounds of protein per acre due to applied N were fairly uniform until early March but then increased in early April. Differences in protein production between applied rates of N were greater at the end of the season than at the beginning. The decrease in pounds of protein per acre in January was more a function of the slight decrease in percent protein at that time than forage yield. The forage yield increase from early February to early April was the dominant factor accounting for more pounds of protein per acre produced then. This was more evident at the 300- and 400-pound rates of N than at the 200-pound rate. Although forage yield continued to increase the remainder of the season, a dilution effect in percent protein occurred, resulting in a decrease in pounds of protein per acre the latter part of the season. This was probably due in part to a shortage of available N.

Table 4. Mean effects of applied N, P, and K on pounds crude protein per acre in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	1629^{a1}	1702^{a3}	1676^{a2}	1669^{a}
300	1918^{b1}	1966^{b2}	1957^{b2}	1947^{b}
400	2133^{c1}	2233^{c2}	2297^{c3}	2221^{c}
Av	1893^{1}	1967^{2}	1977^{3}	1946

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	1667^{a1}	1673^{a1}	1667^{a1}	1669^{a}
300	1890^{b1}	1991^{b3}	1960^{b2}	1947^{b}
400	2138^{c1}	2229^{c2}	2296^{c3}	2221^{c}
Av	1898^{1}	1964^{2}	1974^{3}	1946

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	1806^{a1}	1946^{a3}	1928^{a2}	1893^{a}
200	1930^{b1}	1977^{b2}	1994^{b3}	1967^{b}
300	1959^{c1}	1970^{b2}	2002^{b3}	1977^{c}
Av	1898^{1}	1964^{2}	1974^{3}	1946

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at P∠.05.

Table 5. Effects of applied N, P, and K on the crude protein content (dry matter basis) and pounds crude protein produced per acre in the forage of an oat-ryegrass mixture, five-year average

Pounds per acre N	 P_2O_5	 K_2O	Protein %	Protein lbs/a
200	100	100	24.0^{cdfge}	1585^{e}
200	200	100	24.4^{efgh}	1723^{g}
200	300	100	24.3^{defg}	1691^{g}
200	100	200	23.7^{cdef}	1717^{g}
200	200	200	23.4^{bc}	1661^{f}
200	300	200	23.2^{bc}	1641^{f}
200	100	300	22.7^{b}	1583^{e}
200	200	300	23.7^{cdef}	1722^{g}
200	300	300	23.2^{bc}	1695^{g}
300	100	100	25.0^{ghij}	1857^{h}
300	200	100	25.6^{ijk}	1924^{i}
300	300	100	25.5^{hijk}	1888^{h}
300	100	200	24.9^{ghi}	1948^{ij}
300	200	200	25.4^{hijk}	2047^{l}
300	300	200	24.8^{ghi}	1978^{jk}
300	100	300	24.9^{ghi}	1950^{ij}
300	200	300	24.3^{defg}	1925^{i}
300	300	300	24.5^{fgh}	2005^{k}
400	100	100	27.0^{no}	1975^{j}
400	200	100	27.0^{no}	2142^{m}
400	300	100	27.8^{o}	2296^{pq}
400	100	200	26.6^{lmn}	2174^{n}
400	200	200	26.6^{lmn}	2223^{o}
400	300	200	26.7^{mn}	2291^{p}
400	100	300	27.0^{no}	2250^{o}
400	200	300	26.5^{lmn}	2333^{q}
400	300	300	26.3^{klmn}	2305^{pq}
0	0	0	20.1^{a}	673^{a}
200	0	0	24.7^{ghi}	1282^{c}
200	200	0	24.6^{fghi}	1487^{d}
200	0	200	24.3^{defg}	1469^{d}
0	200	0	20.3^{a}	746^{a}
0	0	200	19.8^{a}	665^{a}
0	200	200	19.6^{a}	753^{b}
300	0	0	25.9^{jklm}	1473^{d}
400	0	0	27.2^{n}	1462^{d}
Year Av				
1966-67			22.7^{b}	1828^{d}
1967-68			22.1^{a}	1690^{b}
1968-69			22.9^{b}	1550^{a}
1969-70			25.4^{c}	1753^{c}
1970-71			27.9^{d}	1865^{e}

Values with same letter superscript not significantly different at $P \angle .05$. Superscripts pertaining to data of fertilizer treatments are not related to the superscripts in the year average portion of the table.

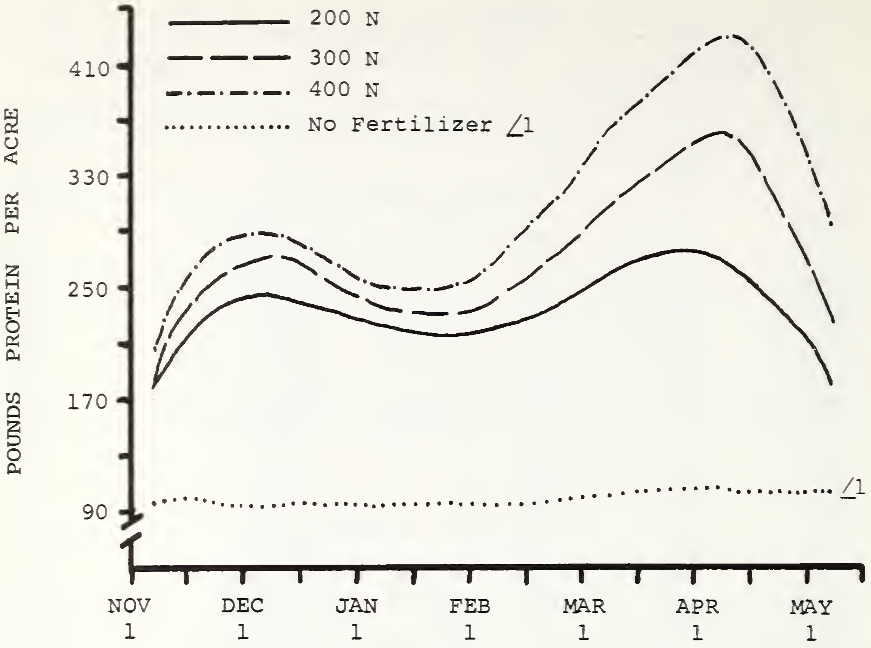

Fig. 6. Mean effects of lbs/a of applied N averaged over 100, 200, and 300 lbs/a of applied P_2O_5 and K_2O on the distribution of pounds crude protein per acre of an oat-ryegrass mixture. Average of seven clippings per year over five years.
∠1 The no fertilizer line is included to provide base line information only.

(b) Phosphorus

Pounds of protein per acre were significantly increased by applied P_2O_5 (Table 4). This was a function of the effect of P_2O_5 on yield only, because P_2O_5 had no effect on percent protein. The protein yield differences occurred from November to mid-January and were mainly between the 100-pound level and the 200- and 300-pound P_2O_5 levels. The P_2O_5 response curve representing pounds of protein per acre over the season was similar to that of the average N curve. There was less than 100 pounds of protein per acre difference among all three levels of applied P_2O_5.

(c) Potassium

Increased K_2O levels significantly increased the pounds of protein per acre (Table 4). The greatest difference in pounds of protein production occurred between the 100-pound level and the 200- and 300-pound K_2O levels from mid-January to early April. The total difference between the 100- and 200-pound levels was 66 pounds of protein per acre; the difference between the 200- and 300-pound levels was only 10 pounds.

(d) Correlations

There was a significant positive correlation between forage yield and pounds of protein. The relationship was lowered because protein production decreased sharply in April while forage yield continued to increase. Decrease in protein production toward the end of the season resulted from maturation, and dilution of the N in the increased forage yield.

The positive correlations of ADF and CWC with pounds of protein per acre are accounted for by the fact that the trend of all these measurements was similar until the latter part of the season. The ADF and CWC continued to increase, whereas pounds protein decreased, thus lowering the relationship.

The negative correlation between DDM and pounds of protein per acre is attributed to the inverse relationship of the two from November to early February.

3. Structural Carbohydrates and *in Vitro* Digestible Dry Matter

Crude protein and crude fiber determinations have been used as measures of forage quality for many years and have contributed considerably to the evaluation of forages for feed. Accepting the limitations of these measures for quality, researchers have continued to investigate other laboratory methods that would more nearly relate laboratory values to animal performance. Two procedures were used in evaluating forage samples obtained throughout this study. One procedure was to fractionate the plant cell into cell content and cell wall constituents. Acid detergent fiber was then separated from the cell wall constituents. The other was an *in vitro* digestible dry matter procedure that simulates rumen conditions.

(a) Percent Cell Wall Constituent

Cell wall constituent (CWC), chemically or physiologically, is the total fibrous fraction of the forage. It includes hemicellulose, cellulose, lignin, and ash. The remainder of a plant cell, apart from CWC, is cell content. Cell content generally includes true protein, other nitrogenous compounds, organic acids, and the more soluble carbohydrates (starches and sugars). Cell content is considered to be approximately 98 percent digestible. Agronomically, little can be done to increase the digestibility of cell content, but the challenge to researchers is to increase the percent cell content or increase the digestibility of its counterpart, CWC. The *in vitro* DDM procedure does not measure the digestibility of CWC per se, but the total dry matter. The ultimate aim of these procedures is to establish an index that most nearly predicts animal performance.

(1) Nitrogen

The mean effect of N on percent CWC was significant (Table 6). The differences were small, but CWC decreased as N levels increased. The CWC

Table 6. Mean effects of applied N, P, and K on percent cell wall constituents (dry matter basis) in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	41.8^{b1}	41.7^{b1}	41.8^{b1}	41.8^{c}
300	41.5^{b1}	41.4^{ab1}	41.5^{b1}	41.5^{b}
400	40.9^{a1}	41.1^{a1}	40.9^{a1}	41.0^{a}
Av	41.4^{1}	41.4^{1}	41.4^{1}	41.4

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	41.6^{b1}	41.9^{b1}	41.8^{b1}	41.8^{c}
300	41.4^{b1}	41.5^{ab1}	41.6^{b1}	41.5^{b}
400	40.9^{a1}	41.1^{a1}	41.0^{a1}	41.0^{a}
Av	41.3^{1}	41.5^{1}	41.5^{1}	41.4

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	41.4^{a1}	41.4^{a1}	41.4^{a1}	41.4^{a}
200	41.2^{a1}	41.6^{a1}	41.5^{a1}	41.4^{a}
300	41.3^{a1}	41.5^{a1}	41.5^{a1}	41.4^{a}
Av	41.3^{1}	41.5^{1}	41.5^{1}	41.4

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P \angle .05$.

of the nonfertilized forage averaged 41.6 percent (Table 10), while that of the 300-pound level of N averaged 41.5 percent. Figure 7 illustrates CWC as an average of all N, P_2O_5, and K_2O levels throughout the season. Response differences of CWC to N were too small to illustrate. CWC increased in November, then generally leveled off until mid-February, and increased at a uniform rate until the end of the season. Season and year differences had significant effects on CWC. The CWC increased from an average of 34 percent at the beginning of the season to 59 percent at the end of the season. The CWC averaged 5.1 percent lower in the 1970-71 season than in the 1967-68 season. The CWC in nonfertilized forage was

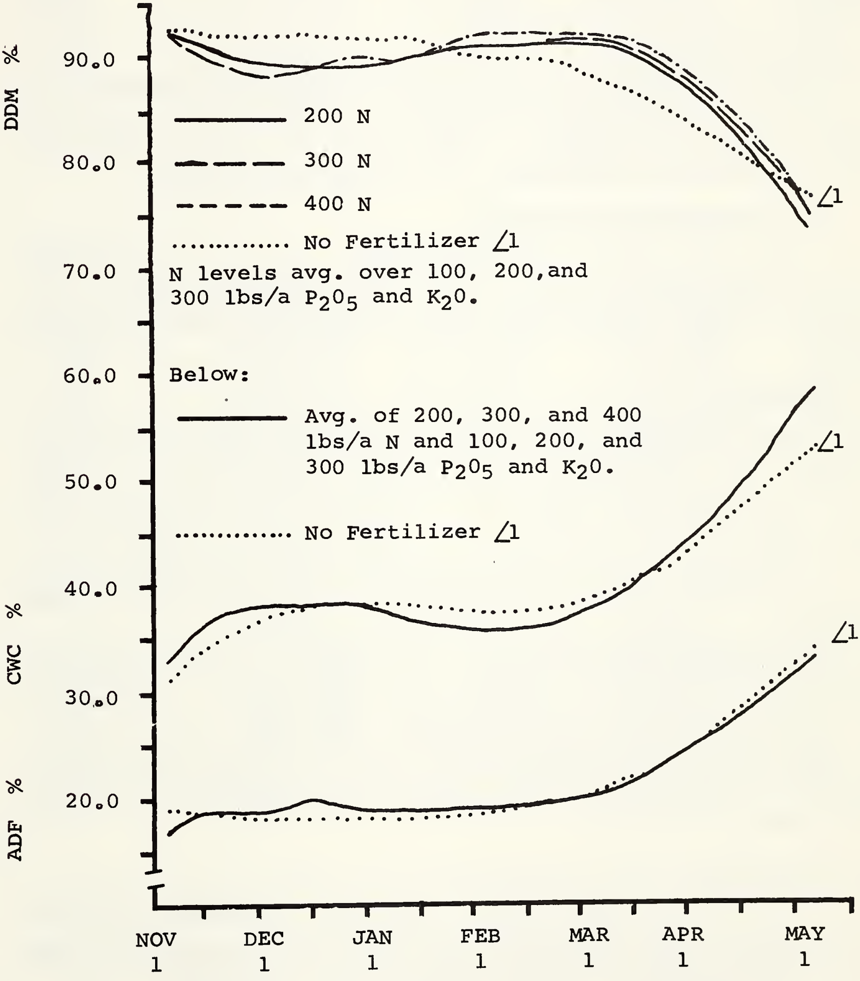

Fig. 7. Mean effects of applied fertilizer on acid-detergent fiber (ADF), cell wall constituents (CWC), and *in vitro* digestible dry matter (DDM) in forage of an oat-ryegrass mixture. Average of seven clippings per year over five years.
∠1 The no fertilizer line is included to provide base line information only.

lower in November and April and higher in January and February than was CWC in the fertilized forage.

(2) Phosphorus

Applied P_2O_5 did not affect the percent CWC through the growing season (Table 6). The CWC response curve to P_2O_5 was similar to the average curve over all the N levels.

(3) Potassium

Applied K_2O had no significant effect on percent CWC in the forage (Table 6).

(4) Correlations

The CWC was significantly correlated with ADF (Table 17). ADF constitutes approximately one-half of the CWC (Figure 7). The significant negative relationship of CWC to DDM reflects the inverse relationship of these two factors, on a percentage basis, throughout the season.

(b) Percent Acid Detergent Fiber

Acid detergent fiber gives a more realistic measure of the fiber that may be digested by a ruminant than does crude fiber because ADF includes the lignin, whereas some lignin is extracted in the crude fiber analysis.

(1) Nitrogen

The ADF decreased significantly as applied N increased (Table 7). The maximum ADF difference was 0.7 percent. The season average of the ADF in the nonfertilized forage was 22.2 percent (Table 10) as compared with 22.1 percent for the overall N effect. Figure 7 illustrates the similarity of the ADF in the fertilized and nonfertilized forage throughout the season. It is doubtful whether these differences could be detected by animal evaluations.

Approximately half of the CWC is ADF (Figure 7). The season curve differed slightly for ADF as compared with CWC. The ADF remained at about 19 percent from the beginning of the season until early March and then increased more gradually to the end of the season than did CWC. The difference in slopes of the ADF and CWC curves indicates probably more hemicellulose accumulation in the forage during the latter part of the season.

(2) Phosphorus

The ADF in the forage was not significantly affected by applied P_2O_5 (Table 7). This indicates that although P has an essential role in plant growth, it is not a significant part of the fibrous fraction.

(3) Potassium

Increased K_2O levels significantly increased ADF in the forage (Table 7). A mean difference of 0.3 percent occurred between the 100- and 200-pound levels of K_2O. The ADF as affected by K_2O was

Table 7. Mean effects of applied N, P, and K on percent acid detergent fiber (dry matter basis) in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	22.5^{b1}	22.5^{b1}	22.4^{c1}	22.5^{c}
300	21.9^{a1}	22.0^{a1}	22.1^{b1}	22.0^{b}
400	21.7^{a1}	21.9^{a1}	21.7^{a1}	21.8^{a}
Av	22.0^{1}	22.1^{1}	22.1^{1}	22.1

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	22.3^{c1}	22.7^{b2}	22.4^{b1}	22.5^{c}
300	21.9^{b1}	21.9^{a1}	22.2^{ab2}	22.0^{b}
400	21.5^{a1}	21.8^{a2}	22.0^{a2}	21.8^{a}
Av	21.9^{1}	22.2^{2}	22.2^{2}	22.1

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	21.9^{a1}	22.1^{a1}	22.1^{a1}	22.0^{a}
200	21.9^{a1}	22.2^{a2}	22.3^{a2}	22.1^{a}
300	21.9^{a1}	22.2^{a2}	22.1^{a12}	22.1^{a}
Av	21.9^{1}	22.2^{2}	22.2^{2}	22.1

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P \angle .05$.

slightly higher from November until mid-February when compared with N effects on ADF. In the remainder of the season, ADF responded similarly to all applied nutrients.

(c) Percent *in Vitro* Digestible Dry Matter

The DDM represents that portion of the forage, both cell content and CWC, that can be utilized by ruminants. Results reported in other studies indicate a high positive correlation between *in vitro* (test tube) DDM values and *in vivo* (animal) DDM values. Therefore, these findings should be used as relative values. It is more difficult to measure small differences in forage quality with the *in vivo* procedure because of animal variation. The small *in vitro* DDM differences that were detected in this study may be of minimal importance to actual animal performance.

The DDM data are reported as *in vitro* "true" digestibility values and not as "apparent" digestibility values. True digestibility is based on only the undigested forage residue, whereas apparent digestibility is based on the forage residue and the microfloral residue. Most of the data cited in literature are presented as apparent digestibility. A high correlation exists between true and apparent digestibility. Therefore, the true DDM values reported herein are valid and relative among treatments. True DDM values are 12 to 15 percent higher than apparent DDM values.

(1) Nitrogen

The DDM in the forage increased significantly as applied N increased (Table 8). The DDM season average increase due to N was 0.6 percent. The DDM season average of the nonfertilized forage was 87.8 percent (Table 10), the same as the average of all N rates.

Response of DDM to applied N throughout the season is illustrated in Figure 7. The DDM decreased slightly in November, remained level until mid-January, and increased slightly until early March, at which time it decreased rapidly until the end of the season. Generally, the effects of N were consistent throughout the season. The DDM of the 200-pound N level was lowest, with the 300-pound level intermediate and the 400-pound level highest. The differences were small throughout the season and of minimal practical importance.

The DDM in nonfertilized forage compared with that of the fertilized forage from the beginning of the season until mid-January is not well understood (Figure 7). The DDM of the nonfertilized forage was identical to that of the fertilized forage initially but then was higher until mid-January, after which time it was lower until late April. An explanation may be that in the early part of the growing season the native fertility status of the nonfertilized soil was in a more desirable balance for plant growth, so as to enhance a more digestible fibrous fraction. Also, CWC in the nonfertilized forage was lower, indicating that the highly digestible cell content was higher. However, as the season progressed, essential plant nutrients became more limited for plant growth, stimulating cell differentiation and maturation in the nonfertilized forage. This is substantiated more by yield and percent protein than by CWC and ADF. Increased lignification, not accounted for, would be a consideration.

Table 8. Mean effects of applied N, P, and K on percent *in vitro* digestible dry matter (dry matter basis) in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	87.4^{a1}	87.6^{a1}	87.6^{a1}	87.5^{a}
300	87.7^{ab1}	87.7^{a1}	87.7^{a1}	87.7^{b}
400	88.1^{b12}	88.0^{a1}	88.3^{b2}	88.1^{c}
Av	87.8^{1}	87.8^{1}	87.8^{1}	87.8

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	87.5^{a1}	87.6^{a1}	87.4^{a1}	87.5^{a}
300	87.6^{a1}	87.7^{a1}	87.8^{ab1}	87.7^{b}
400	88.1^{b1}	88.3^{b1}	88.1^{b1}	88.1^{c}
Av	87.7^{1}	87.9^{1}	87.8^{1}	87.8

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	87.5^{a1}	88.0^{a2}	87.8^{a2}	87.8^{a}
200	87.9^{a2}	87.6^{a1}	87.9^{a2}	87.8^{a}
300	87.9^{a12}	88.0^{a2}	87.7^{a1}	87.8^{a}
Av	87.7^{1}	87.9^{1}	87.8^{1}	87.8

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P \angle .05$.

(2) Phosphorus

On the average, level of applied P_2O_5 did not significantly alter the DDM in the forage (Table 8).

(3) Potassium

Overall, level of applied K_2O did not significantly alter the DDM in the forage (Table 8).

The response curves of DDM at all rates of applied P_2O_5 and K_2O were essentially the same as the curve averaged over all rates of applied N (Figure 7).

(d) Pounds *in Vitro* Digestible Dry Matter per Acre

A measure of pounds of DDM per acre contributes to the evaluation of response of this forage mixture to applied fertilizer. It gives more insight into the quality aspects on a per acre basis. Pounds DDM per acre provides a better economic evaluation of the forage than does yield alone. It represents, to a relative degree, the portion of the forage utilized by ruminants.

(1) Nitrogen

There was a significant response in pounds DDM to applied N (Table 9). A 652-pound increase was noted at the 300-pound level over the 200-pound level of N, and a 445-pound increase at the 400-pound level over the 300-pound level of N. The DDM yield of the nonfertilized forage was about half that of the forage that received 200 pounds of N (Table 10).

The response curves of DDM yield shown in Figure 8 are similar to the response curves of forage yield in Figure 1. Although applied N had a significant effect on percent DDM throughout the season, the effects were of a relatively small magnitude. Thus, pounds DDM per acre was more a function of season effect and forage yield than percent DDM. The significant difference occurred mainly in March and April between the 200- and 300-pound levels of N.

(2) Phosphorus

There was a significant response in pounds of DDM per acre to each increase in applied P_2O_5 even though the season averages were comparatively small (Table 9).

Pounds DDM per acre generally increased throughout the season with each increase in P_2O_5 (Figure 9). Response to 100 pounds of applied P_2O_5 was lower than response to the other P_2O_5 levels in November, December, and April, and higher in January and February.

(3) Potassium

Applied K_2O had a significant effect on pounds DDM per acre. This was a function of forage yield response to K_2O levels and not a response of percent DDM to applied K_2O. As with forage yield, a greater difference in pounds DDM per acre occurred at 200 pounds of K_2O per acre over 100 pounds per acre than at 300 pounds of K_2O over 200 pounds per acre (Table 9). The DDM yield difference due to applied K_2O occurred mainly from March to the end of the growing season (Figure 10).

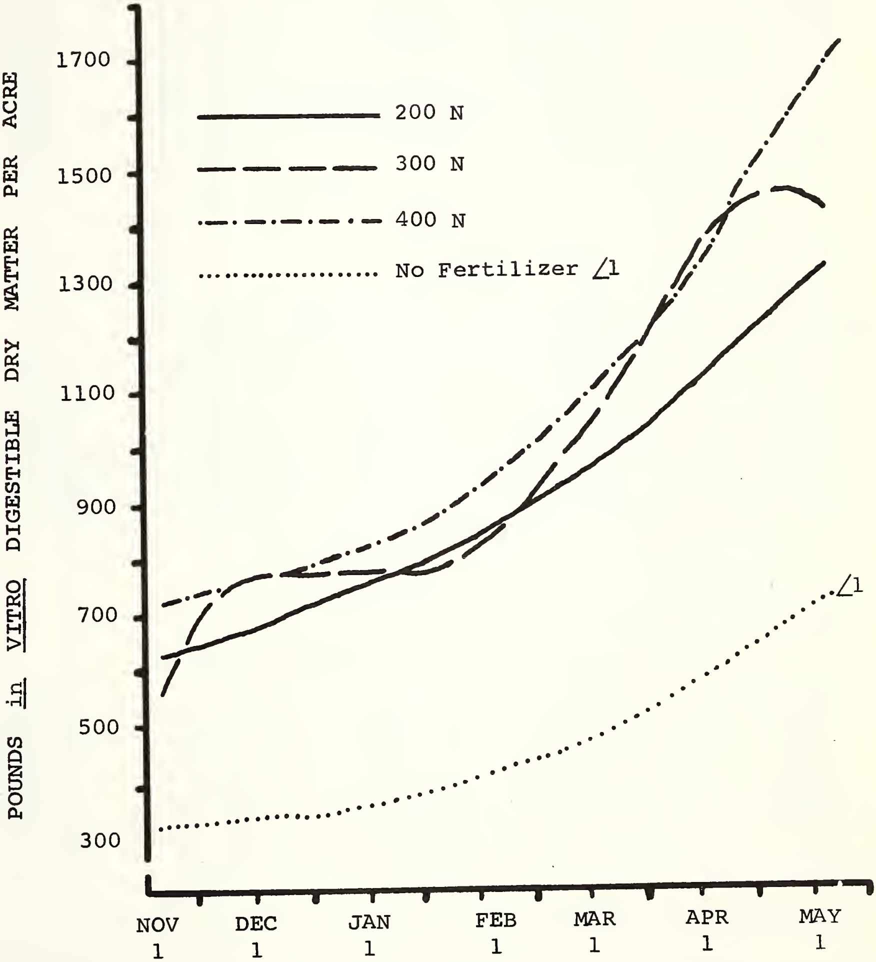

Fig. 8. Mean effects of lbs/a of applied N averaged over 100, 200, and 300 lbs/a of applied P_2O_5 and K_2O on pounds *in vitro* digestible dry matter (DDM) in forage of an oat-ryegrass mixture. Average of seven clippings per year over five years.
∠1 The no fertilizer line is included to provide base line information only.

Table 9. Mean effects of applied N, P, and K on pounds *in vitro* digestible dry matter per acre in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	6419^{a1}	6564^{a2}	6597^{a3}	6527^{a}
300	7090^{b1}	7215^{b2}	7230^{b2}	7179^{b}
400	7313^{c1}	7709^{c2}	7851^{c3}	7624^{c}
Av	6941^{1}	7163^{2}	7226^{3}	7110

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	6355^{a1}	6605^{a2}	6620^{a2}	6527^{a}
300	6837^{b1}	7319^{b2}	7380^{b3}	7179^{b}
400	7200^{c1}	7732^{c2}	7942^{c3}	7624^{c}
Av	6797^{1}	7218^{2}	7314^{3}	7110

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	6526^{a1}	7161^{a2}	7135^{a2}	6941^{a}
200	6913^{b1}	7212^{b2}	7363^{b3}	7163^{b}
300	6953^{c1}	7282^{c2}	7444^{c3}	7226^{c}
Av	6797^{1}	7218^{2}	7314^{3}	7110

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P \angle .05$.

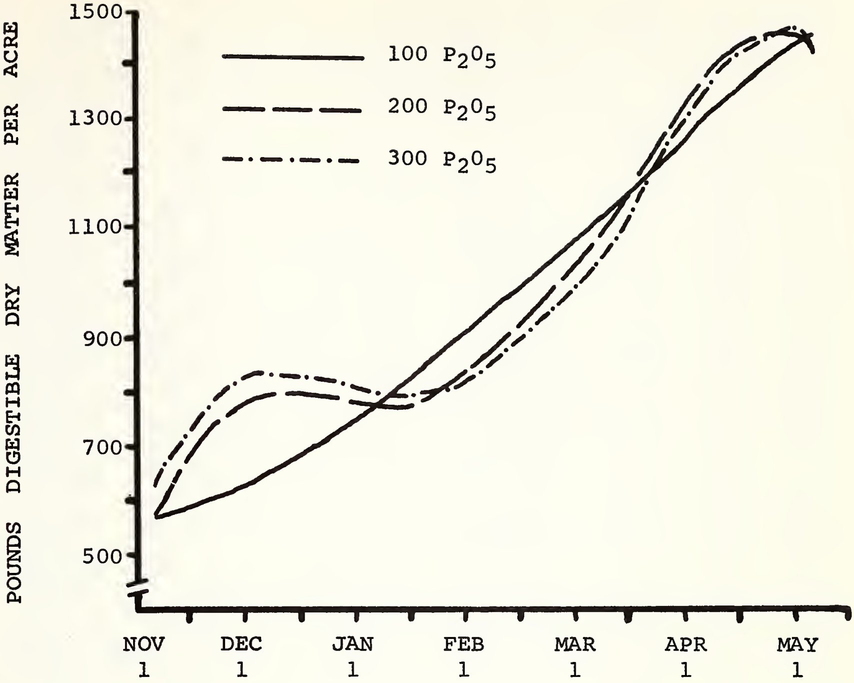

Fig. 9. Mean effects of lbs/a of applied P_2O_5 averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied K_2O on pounds in vitro digestible dry matter (DDM) per acre in forage of an oat-ryegrass mixture. Average of seven clippings per year over five years.

Table 10. Effects of applied N, P, and K on several quality measurements (dry matter basis) in the dry forage of an oat-ryegrass mixture, five-year average

Pounds per acre			CWC	ADF	DDM	DDM
N	P_2O_5	K_2O	%	%	%	lbs/a
200	100	100	41.8^{bcd}	22.6^{cde}	87.0^{a}	6058^{g}
200	200	100	41.4^{abcd}	22.3^{bcde}	87.7^{ab}	6503^{hi}
200	300	100	41.6^{abcd}	22.1^{bcde}	87.8^{ab}	6505^{hi}
200	100	200	41.8^{bcd}	22.8^{e}	87.8^{ab}	6740^{jk}
200	200	200	42.0^{cd}	22.7^{de}	87.4^{ab}	6487^{h}
200	300	200	41.9^{bcd}	22.5^{bcde}	87.7^{ab}	6588^{i}
200	100	300	41.9^{bcd}	22.2^{bcde}	87.4^{ab}	6461^{h}
200	200	300	41.7^{abcd}	22.4^{bcde}	87.7^{ab}	6702^{jk}
200	300	300	41.9^{bcd}	22.5^{cde}	87.2^{a}	6697^{j}
300	100	100	41.3^{abcd}	21.6^{ab}	87.6^{ab}	6795^{k}
300	200	100	41.4^{abcd}	22.0^{bcd}	87.7^{ab}	6911^{l}
300	300	100	41.5^{abcd}	22.1^{bcde}	87.4^{ab}	6803^{k}
300	100	200	41.6^{abcd}	22.0^{bcd}	87.7^{ab}	7204^{m}
300	200	200	41.5^{abcd}	21.7^{b}	87.5^{ab}	7422^{o}
300	300	200	41.5^{abcd}	22.1^{bcde}	87.8^{ab}	7330^{n}
300	100	300	41.6^{abcd}	22.1^{bcde}	88.0^{ab}	7272^{mn}
300	200	300	41.5^{abcd}	22.3^{bcde}	87.8^{ab}	7312^{n}
300	300	300	41.6^{abcd}	22.1^{bcde}	87.8^{ab}	7557^{p}
400	100	100	41.1^{abcd}	21.4^{ab}	87.9^{ab}	6725^{jk}
400	200	100	40.8^{ab}	21.5^{ab}	88.1^{ab}	7326^{n}
400	300	100	40.7^{a}	21.5^{ab}	88.4^{b}	7550^{p}
400	100	200	41.0^{abc}	21.6^{ab}	88.4^{b}	7540^{p}
400	200	200	41.2^{abcd}	22.1^{bcde}	88.0^{ab}	7728^{q}
400	300	200	41.2^{abcd}	21.9^{bc}	88.4^{b}	7927^{r}
400	100	300	40.8^{ab}	22.0^{bcd}	88.0^{ab}	7673^{q}
400	200	300	41.3^{abcd}	22.2^{bcde}	88.1^{ab}	8075^{s}
400	300	300	40.8^{ab}	21.8^{b}	88.1^{ab}	8077^{s}
0	0	0	41.6^{abcd}	22.2^{bcde}	87.8^{ab}	3262^{a}
200	0	0	41.2^{abcd}	21.5^{ab}	87.9^{ab}	4932^{c}
200	200	0	41.5^{abcd}	22.1^{bcde}	88.0^{ab}	5708^{f}
200	0	200	41.1^{abcd}	21.9^{bc}	88.1^{ab}	5745^{f}
0	200	0	41.9^{bcd}	22.2^{bcde}	87.6^{ab}	3521^{b}
0	0	200	41.9^{bcd}	22.3^{bcde}	86.9^{a}	3277^{a}
0	200	200	42.2^{d}	22.8^{e}	87.6^{ab}	3590^{b}
300	0	0	40.6^{a}	21.5^{ab}	87.7^{ab}	5352^{e}
400	0	0	40.8^{ab}	21.0^{a}	88.1^{ab}	5086^{d}
Year Av						
1966-67			41.5^{c}	23.4^{d}	86.4^{b}	7554^{e}
1967-68			44.9^{d}	25.0^{e}	69.1^{a}	5292^{a}
1968-69			41.4^{c}	21.6^{c}	94.3^{e}	6265^{b}
1969-70			40.6^{b}	21.0^{b}	92.7^{d}	6868^{d}
1970-71			39.8^{a}	20.4^{a}	92.3^{c}	6304^{c}

Values with same letter superscript not significantly different at $P \leq .05$. Superscripts pertaining to data of fertilizer treatments are not related to the superscripts in the year average portion of the table.

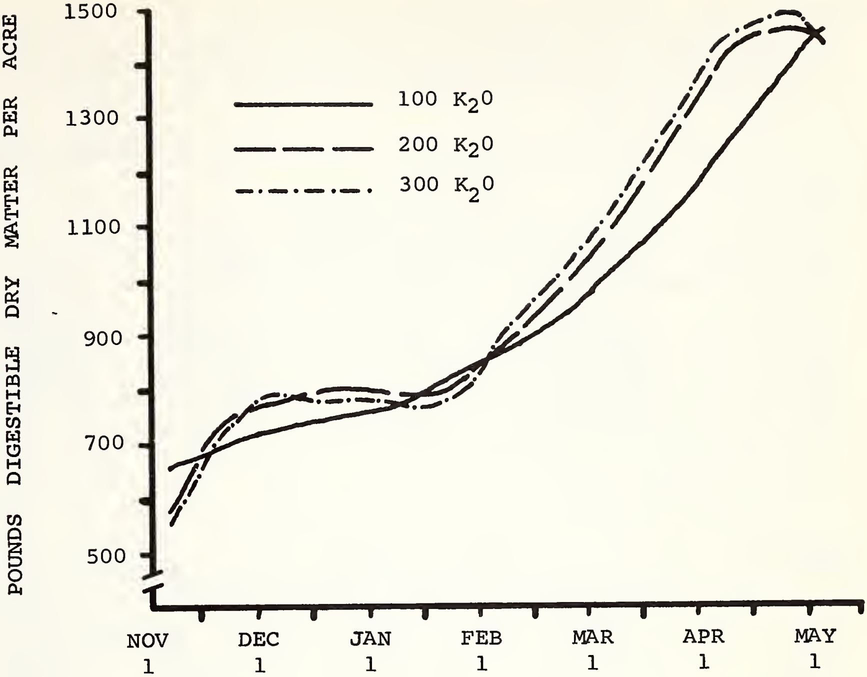

Fig. 10. Mean effects of lbs/a of applied K_2O averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied P_2O_5 on pounds in vitro digestible dry matter (DDM) per acre in forage of an oat-ryegrass mixture. Average of seven clippings per year over five years.

4. Mineral Determinations

(a) Phosphorus Content

Phosphorus has an essential role in plant growth. The P content in forage is nutritionally important in the diet of a ruminant. Its role in the animal's diet and health is not completely understood. Both the percent phosphorus in the forage and the ratio of it to other minerals are important. A range of 0.26 to 0.32 percent P is considered adequate for a beef cow with a calf.

(1) Nitrogen

Applied N had a significant effect on percent P in the forage (Table 11) but the mean difference was small and probably of no real importance. More pronounced differences among N levels were detected within P_2O_5 levels. The differences in P content in the forage throughout the season between applied N rates varied from 0.1 percent in November and December to 0.2 percent from mid-March through the remainder of the season. There was a significant N x clipping date interaction, indicating that all N levels did not affect P in the forage alike at all clippings. Phosphorus in the forage was lower at the 200-pound rate of N than at

Table 11. Mean effects of applied N, P, and K on percent phosphorus (dry matter basis) in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	0.36^{a1}	0.40^{a2}	0.44^{b3}	0.40^{b}
300	0.36^{a1}	0.40^{a2}	0.43^{ab3}	0.40^{b}
400	0.35^{a1}	0.39^{a2}	0.42^{a3}	0.39^{a}
Av	0.36^{1}	0.40^{2}	0.43^{3}	0.40

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	0.39^{a1}	0.40^{b1}	0.40^{ab1}	0.40^{b}
300	0.39^{a1}	0.40^{b12}	0.41^{b2}	0.40^{b}
400	0.40^{a2}	0.38^{a1}	0.39^{a12}	0.39^{a}
Av	0.39^{1}	0.39^{1}	0.40^{2}	0.40

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	0.35^{a1}	0.36^{a1}	0.36^{a1}	0.36^{a}
200	0.40^{b1}	0.39^{b1}	0.40^{b1}	0.40^{b}
300	0.43^{c1}	0.43^{c1}	0.43^{c1}	0.43^{c}
Av	0.39^{1}	0.39^{1}	0.40^{2}	0.40

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at P∠.05.

the other N rates until mid-February and then higher for the remainder of the season. Significant differences did not occur between the 200- and 300-pound N rates during the first half of the season, or between the 100- and 200-pound rates the last half of the season.

(2) *Phosphorus*

Applied P_2O_5 significantly increased the P content of the forage (Table 11). The season average increase of P from the 200- and 300-pound levels of P_2O_5 was 0.04 percent and 0.07 percent, respectively, over the 100-pound rate. The P content of the nonfertilized forage was 0.33 percent (Table 15).

Figure 11 illustrates the response of P content to applied P_2O_5 throughout the season. Differences in P content of forage due to applications of P_2O_5 were fairly consistent, but were greater in midwinter than at the beginning and end of the season. A quadratic response was noted, with the peak in mid-January. Percentages of P were identical at the beginning and ending of the season for 100 pounds of P_2O_5 per acre. The P percentages were slightly lower at end of the season as compared with the beginning of the season for the 200- and 300-pound P_2O_5 applications. The P contents of the fertilized and nonfertilized forages were well within the range considered adequate for beef cows.

(3) *Potassium*

Phosphorus content in the forage was significantly higher by 0.01 percent with 300 pounds of K_2O per acre over the two lower rates (Table 11). This small increase is probably of no practical importance.

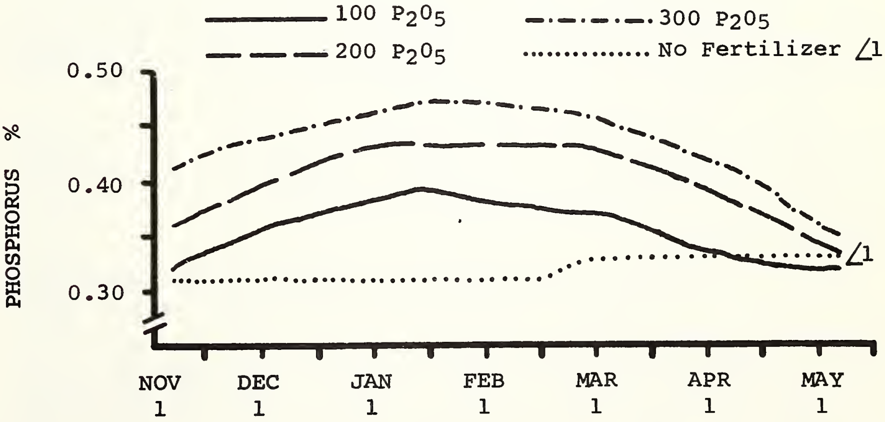

Fig. 11. Mean effects of lbs/a of applied P_2O_5 averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied K_2O on the phosphorus content in forage of an oat-ryegrass mixture. Average of seven clippings per year over five years.
∠1 The no fertilizer line is included to provide base line information only.

(4) Correlations

The high correlation between percent P and K in the forage (Table 17) was due in part to the decline of both nutrients in the latter half of the season (Figures 11, 12). The mineral ratios in forage are important with regard to animal nutrition. The P to Ca ratio of the forage was initially a 1:1 ratio with 100 pounds each of applied P_2O_5 and K_2O. As the season progressed, the ratio was 1.0:1.2 in mid-December, 1.0:1.1 in mid-January, 1.0:1.4 in mid-March, 1.0:1.7 in mid-April, and 1.0:1.5 at the end of the season. The P to Mg ratios were 1.0:0.69, 1:0:0.86, 1.0:0.79, 1.0:0.89, 1.0:1.03, and 1.0:1.0, respectively, for the same periods.

(b) Potassium Content

Potassium is an essential major plant nutrient. Plants can accumulate excessive levels of K, a condition commonly referred to as "luxury consumption." It is estimated that a range of 1.8 to 2.1 percent K in the forage is adequate for a beef cow with a calf. The animal apparently excretes excess K without difficulty. It is speculated that K plays an important role in a ruminant by helping maintain a proper pH in the saliva and rumen, and in the diet of the rumen microflora. The ratio of K to other mineral elements in the ruminant diet is important but not well understood. Potassium is also involved with the grass tetany syndrome.

(1) Nitrogen

Levels of N had a significant but inconsistent effect on K content of the forage. The numerical differences among the mean nitrogen effects were small (Table 12). The season average of K content in the forage was higher at the 300-pound level of N than at 200 or 400 pounds.

The differences in K content as affected by applied N throughout the season were small. The widest range between N levels occurred in February and April. Differences in K content due to N levels were too small to be considered important in either plant or animal nutrition.

(2) Phosphorus

There was no significant overall effect of applied P_2O_5 on the K content of the forage (Table 12).

(3) Potassium

The K content of the forage responded significantly to applied K_2O (Table 12). The K content increased with each increased level of K_2O. The difference was greater between the 100- and 200-pound applications of K_2O than between the 200- and 300-pound applications. The K content was approximately 4.5 percent in early November and gradually declined throughout the season to about 2.2 percent (Figure 12). The nonfertilized forage was higher in K content throughout the season than was the forage that received 100 pounds of K_2O. This probably was a result of a dilution effect of the K due to the increased yield stimulated by the applied fertilizer. The K content showed a linear decrease throughout the season to 100 pounds of applied K_2O, whereas the K decrease at the higher rates was less dramatic until the latter part of the season.

Table 12. Mean effects of applied N, P, and K on percent potassium (dry matter basis) in forage of an oat-ryegrass mixture, five-year average

Lbs/a N	Lbs/a P_2O_5 100	 200	 300	 Av
200	3.29^{a1}	3.22^{a1}	3.25^{a1}	3.25^{a}
300	3.43^{b2}	3.29^{ab1}	3.45^{b2}	3.39^{b}
400	3.28^{a1}	3.40^{b2}	3.21^{a1}	3.29^{a}
Av	3.33^{1}	3.30^{1}	3.30^{1}	3.31

Lbs/a N	Lbs/a K_2O 100	 200	 300	 Av
200	2.62^{a1}	3.44^{ab2}	3.70^{a3}	3.25^{a}
300	2.80^{b1}	3.52^{b2}	3.85^{b3}	3.39^{b}
400	2.66^{a1}	3.39^{a2}	3.83^{b3}	3.29^{a}
Av	2.69^{1}	3.45^{2}	3.79^{3}	3.31

Lbs/a P_2O_5	Lbs/a K_2O 100	 200	 300	 Av
100	2.71^{a1}	3.42^{a2}	3.86^{b3}	3.33^{a}
200	2.66^{a1}	3.52^{a2}	3.72^{a3}	3.30^{a}
300	2.71^{a1}	3.41^{a2}	3.79^{ab3}	3.30^{a}
Av	2.69^{1}	3.45^{2}	3.79^{3}	3.31

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P \angle .05$.

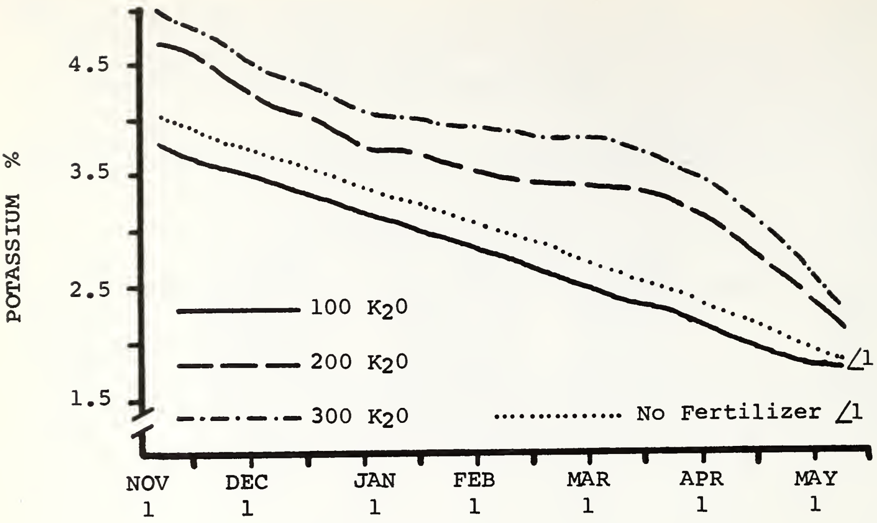

Fig. 12. Mean effects of lbs/a of applied K_2O averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied P_2O_5 on the potassium content in the forage of an oat-ryegrass mixture. Average of seven clippings per year over five years.
∠1 The no fertilizer line is included to provide base line information only.

(4) Correlations

Potassium content was negatively correlated with Ca and Mg (Table 17). This was due in part to the fact that K decreased until the end of the season. Potassium content was negatively correlated with CWC and ADF, but was positively correlated with DDM. Most of the K in forage is found in the cell content. Thus, as CWC and ADF increased, the cell content decreased, with a corresponding reduction in the amount of K relative to the decrease in cell content. This does not imply that K content increased digestibility of the forage per se. It was more a matter that the K was located in the plant cell content, which is the more digestible forage constituent.

(c) Calcium Content

Calcium has long been recognized as an essential secondary plant nutrient, and also an essential and major mineral in animal nutrition. A Ca content of 0.22 to 0.25 percent in forages is considered adequate for beef cows. Forage yields of grasses have not shown a large response to applications of Ca, generally a lime material. The Ca content of the forage can be increased by applying Ca periodically.

(1) Nitrogen

There was a significant response in Ca content of the forage to applied N. Calcium increased as levels of N were increased (Table 13), partially due to the plant's necessity to maintain cell content ionic balance. The Ca content increased 0.02 percent with each increase of N. The average Ca content of nonfertilized forage was 0.35 percent (Table 15).

Calcium content was affected little by applied N at the beginning of the season. Response of calcium to all N levels then increased until mid-December, then declined until February. The lower temperature and higher soil moisture conditions possibly decreased the availability of soil Ca during this time. From February to mid-April, calcium content increased more rapidly in response to the 300- and 400-pound N levels than to the 200-pound level. It declined uniformly at all N levels from mid-April to the end of the season. Calcium was lower by 0.10 to 0.13 percent at the beginning of the season than at the end.

(2) Phosphorus

There was a significant increase in Ca content of the forage due to applied P_2O_5 (Table 13). The significant P x K and N x P x K interactions indicate that the influence of P_2O_5 levels on the Ca content varied among the N levels and the K_2O levels. However, the numerical values of these interactions were small. The increase in Ca due to applied P_2O_5 over all N and K_2O rates was only 0.01 percent and of little practical importance. The Ca at the 100-pound rate of P_2O_5 was lower than that at the other two rates from mid-January to mid-February but higher in mid-April. Forage from the 300-pound P_2O_5 level was slightly higher in Ca than forage from the 200-pound level during the last half of the season, but the two were similar for the first half of the season.

(3) Potassium

Increasing the K_2O levels significantly decreased the Ca content of the forage (Table 13). Applied K_2O affected the Ca content more than did applied N and P_2O_5. The effect of applied N on increasing the Ca content was lessened as applied K_2O was increased. Calcium content was highest (0.47 percent) when 400 pounds of N and 100 pounds of K_2O were applied, and lowest (0.35 percent) when 200 pounds of N and 300 pounds of K_2O were applied. The Ca content of the latter was essentially the same as that in the nonfertilized forage (Table 15). These data indicate some of the consequences that amounts and ratios of applied plant nutrients may have on mineral concentrations in plants.

The Ca content generally increased throughout the growing season (Figure 13). The difference in Ca content throughout the season was greater between the 100-pound and the 200-pound applications than between the 200- and 300-pound applications of K_2O. There was a decline in Ca content in the latter part of the season, but calcium was still higher at the end of the season than at the beginning. Season effect and year effect on Ca content were significant.

(4) Correlations

The positive correlation beteeen Ca and Mg was significant (Table 17). Both elements are cations and may to a degree substitute for each other in plants. The correlation of Ca with CWC and ADF was positive

Table 13. Mean effects of applied N, P, and K on percent calcium (dry matter basis) in forage of an oat-ryegrass mixture, five-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	0.37^{a1}	0.38^{a2}	0.39^{a3}	0.38^{a}
300	0.40^{b1}	0.41^{b2}	0.41^{b2}	0.40^{b}
400	0.43^{c2}	0.42^{c1}	0.43^{c2}	0.42^{c}
Av	0.40^{1}	0.40^{1}	0.41^{2}	0.40

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	0.43^{a3}	0.37^{a2}	0.35^{a1}	0.38^{a}
300	0.44^{b3}	0.39^{b2}	0.37^{b1}	0.40^{b}
400	0.47^{c3}	0.42^{c2}	0.38^{c1}	0.42^{c}
Av	0.45^{3}	0.39^{2}	0.37^{1}	0.40

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	0.43^{a3}	0.39^{a2}	0.37^{a1}	0.40^{a}
200	0.46^{c3}	0.39^{a2}	0.37^{a1}	0.40^{a}
300	0.45^{b3}	0.40^{b2}	0.37^{a1}	0.41^{b}
Av	0.45^{3}	0.39^{2}	0.37^{1}	0.40

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P \angle .05$.

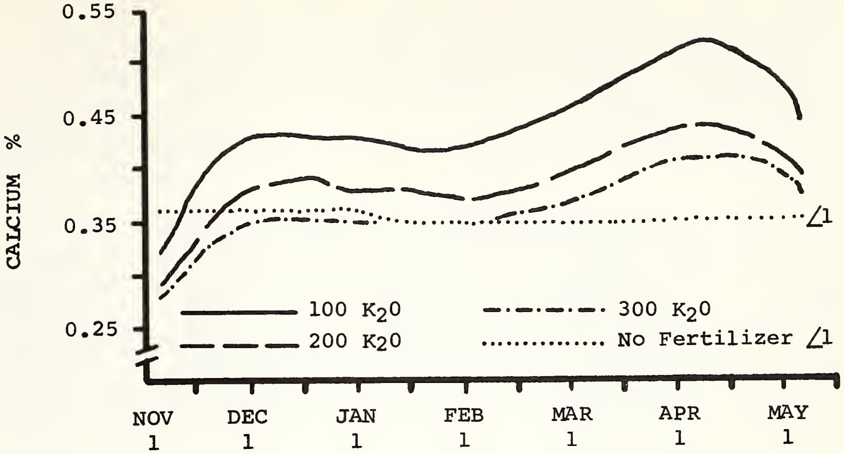

Fig. 13. Mean effects of lbs/a of applied K_2O averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied P_2O_5 on the calcium content in forage of an oat-ryegrass mixture. Average of seven clippings per year over five years.
∠1 The no fertilizer line is included to provide base line information only.

but low. When Ca is available in an adequate amount for plant growth, it has little effect on CWC and ADF. Percent Ca was not related to DDM.

(d) Magnesium Content

Magnesium is an essential plant nutrient. It is also vitally important in the diet of a ruminant. The ratio of Mg to other minerals is important in animal nutrition. A Mg content of 0.16 to 0.20 percent in the forage is considered adequate for a beef cow and calf.

Magnesium is generally applied as a plant nutrient in the form of dolomitic limestone.

(1) Nitrogen

Applied nitrogen had a significant effect on Mg content of the forage (Table 14). There was a 0.01 percent increase in Mg with each increase of N above the 200-pound level.

A Mg content of approximately 0.21 percent was noted for all N levels at the beginning of the season. It then increased until mid-December, but with small differences. Magnesium remained fairly constant until early March. Thereafter, Mg decreased from 0.26 to 0.21 percent at the 200-pound N level, whereas at the 300- and 400-pound levels the Mg content increased slightly until early April and then declined. Magnesium in the nonfertilized forage was higher than that of the fertilized forage at the beginning of the season, but became slightly lower as the season progressed. It decreased to a low of 0.20 percent in March, and increased through early May to 0.26 percent.

In all cases, Mg content throughout the season was at or above the range considered adequate for beef cows.

Table 14. Mean effects of applied N, P, and K on percent magnesium (dry matter basis) in forage of an oat-ryegrass mixture, four-year average

Lbs/a	Lbs/a P_2O_5			
N	100	200	300	Av
200	0.25^{a1}	0.27^{a3}	0.26^{a2}	0.26^{a}
300	0.26^{b1}	0.27^{a2}	0.27^{b2}	0.27^{b}
400	0.28^{c1}	0.28^{b1}	0.29^{c2}	0.28^{c}
Av	0.26^{1}	0.27^{2}	0.27^{2}	0.27

Lbs/a	Lbs/a K_2O			
N	100	200	300	Av
200	0.30^{a3}	0.25^{a2}	0.23^{a1}	0.26^{a}
300	0.30^{a3}	0.26^{b2}	0.24^{b1}	0.27^{b}
400	0.32^{b3}	0.28^{c2}	0.25^{c1}	0.28^{c}
Av	0.31^{3}	0.26^{2}	0.24^{1}	0.27

Lbs/a	Lbs/a K_2O			
P_2O_5	100	200	300	Av
100	0.29^{a3}	0.26^{a2}	0.24^{a1}	0.26^{a}
200	0.31^{b3}	0.26^{a2}	0.24^{a1}	0.27^{b}
300	0.31^{b3}	0.26^{a2}	0.24^{a1}	0.27^{b}
Av	0.31^{3}	0.26^{2}	0.24^{1}	0.27

Values with same letter superscript in vertical columns and same number superscript in horizontal lines are not significantly different at $P \angle .05$.

(2) Phosphorus

There was a small but significant increase in Mg content due to applied P_2O_5 (Table 14). The differences occurred from mid-November to mid-January and were between the 100-pound P_2O_5 application and the 200- and 300-pound applications.

(3) Potassium

Increased K_2O levels significantly decreased Mg content of the forage (Table 14). Response to levels of K_2O was similar throughout the growing season (Figure 14), and the inverse relationship between applied K_2O and Mg content was evident. Magnesium in forage that received 100 pounds of K_2O increased above 0.30 percent in November and remained at or above that level until the end of the season. The difference in Mg content between the 200- and 300-pound K_2O levels was less than that between the 100- and 200-pound levels. The Ca to Mg ratios were 1.0:0.67 initially, 1.0:0.72 in mid-December, 1.0:0.70 in mid-January, 1.0:0.65 in mid-March, 1.0:0.62 in mid-April, and 1.0:0.60 at the end of the season.

(4) Correlations

There was no significant correlation of Mg with CWC or ADF. The low significant correlation of Mg with DDM was probably due in part to the fact that both decreased in the latter part of the season. Magnesium is utilized by plants in the cell protoplasm. Thus, as the highly digestible cell content which contained the Mg decreased in the spring, DDM decreased accordingly.

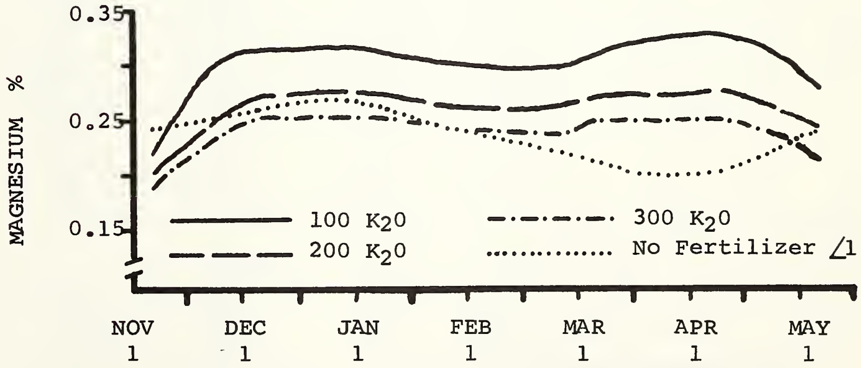

Fig. 14. Mean effects of lbs/a of applied K_2O averaged over 200, 300, and 400 lbs/a of applied N and 100, 200, and 300 lbs/a of applied P_2O_5 on the magnesium content in forage of an oat-ryegrass mixture. Average of 7.25 clippings per year over four years.
/1 The no fertilizer line is included to provide base line information only.

Table 15. Effects of applied N, P, and K on the content of several minerals in the dry forage of an oat-ryegrass mixture, five-year average

Pounds per acre			P	K	Ca	Mg*
N	P_2O_5	K_2O	%	%	%	%
200	100	100	0.34^{de}	2.69^{cde}	0.40^{efgh}	0.28^{h}
200	200	100	0.41^{h}	2.57^{c}	0.44^{ijkl}	0.31^{ij}
200	300	100	0.43^{i}	2.59^{cd}	0.45^{jklm}	0.31^{ij}
200	100	200	0.37^{f}	3.39^{gh}	0.37^{cde}	0.24^{de}
200	200	200	0.39^{g}	3.47^{ghi}	0.36^{bcd}	0.25^{ef}
200	300	200	0.43^{i}	3.46^{ghi}	0.37^{cde}	0.24^{de}
200	100	300	0.36^{ef}	3.78^{jkl}	0.33^{ab}	0.21^{ab}
200	200	300	0.40^{gh}	3.60^{hij}	0.35^{bc}	0.24^{de}
200	300	300	0.45^{j}	3.70^{ijk}	0.36^{bcd}	0.22^{bc}
300	100	100	0.35^{e}	2.97^{f}	0.42^{ghij}	0.28^{h}
300	200	100	0.40^{gh}	2.56^{c}	0.46^{klm}	0.31^{ij}
300	300	100	0.42^{hi}	2.88^{ef}	0.45^{jklm}	0.30^{i}
300	100	200	0.37^{f}	3.46^{ghi}	0.39^{defg}	0.26^{fg}
300	200	200	0.40^{gh}	3.60^{hij}	0.40^{efgh}	0.27^{gh}
300	300	200	0.43^{i}	3.49^{ghi}	0.40^{efgh}	0.26^{fg}
300	100	300	0.36^{ef}	3.85^{kl}	0.37^{cde}	0.24^{de}
300	200	300	0.41^{h}	3.72^{ijkl}	0.37^{cde}	0.24^{de}
300	300	300	0.44^{ij}	3.98^{l}	0.37^{cde}	0.25^{ef}
400	100	100	0.35^{e}	2.47^{bc}	0.48^{m}	0.32^{jk}
400	200	100	0.40^{gh}	2.84^{def}	0.47^{lm}	0.31^{ij}
400	300	100	0.44^{ij}	2.67^{cde}	0.47^{lm}	0.33^{k}
400	100	200	0.34^{de}	3.41^{gh}	0.41^{fghi}	0.28^{h}
400	200	200	0.38^{fg}	3.50^{ghi}	0.40^{efgh}	0.27^{gh}
400	300	200	0.42^{hi}	3.26^{g}	0.44^{ijkl}	0.28^{h}
400	100	300	0.35^{e}	3.95^{l}	0.39^{defg}	0.25^{ef}
400	200	300	0.40^{gh}	3.85^{kl}	0.38^{cdef}	0.25^{ef}
400	300	300	0.41^{h}	3.69^{ijk}	0.37^{cde}	0.26^{fg}
0	0	0	0.33^{d}	2.95^{f}	0.35^{bc}	0.24^{de}
200	0	0	0.30^{bc}	2.22^{a}	0.43^{hijk}	0.30^{i}
200	200	0	0.40^{gh}	2.33^{ab}	0.44^{ijkl}	0.30^{i}
200	0	200	0.28^{a}	3.51^{ghi}	0.34^{abc}	0.23^{cd}
0	200	0	0.41^{h}	2.63^{cde}	0.36^{bcd}	0.25^{ef}
0	0	200	0.31^{c}	3.25^{g}	0.33^{ab}	0.20^{a}
0	200	200	0.39^{g}	3.42^{gh}	0.31^{a}	0.21^{ab}
300	0	0	0.31^{c}	2.14^{a}	0.45^{jklm}	0.31^{ij}
400	0	0	0.29^{ab}	2.28^{ab}	0.44^{ijkl}	0.30^{i}
Year Av						
1966-67			0.29^{a}	2.76^{a}	0.47^{d}	
1967-68			0.33^{b}	2.72^{a}	0.37^{b}	0.25^{a}
1968-69			0.38^{c}	3.04^{b}	0.35^{a}	0.25^{a}
1969-70			0.43^{d}	3.44^{c}	0.37^{b}	0.26^{b}
1970-71			0.43^{d}	3.62^{d}	0.43^{c}	0.29^{c}

*Four years only.

Values with same letter superscript not significantly differently at P∠.05. Superscripts pertaining to date of fertilizer treatments are not related to the superscripts in the year average portion of the table.

SUMMARY AND CONCLUSIONS

1. Nitrogen

Dry forage yield of an oat-ryegrass mixture was significantly increased by applications of N through 400 pounds per acre. Efficiency of utilization of applied N as reflected in yield was greatest with 200 pounds of N. Efficiency decreased as rates of applied N increased. There was no statistical difference in forage yield among N levels until late February. Nitrogen applications altered yield distribution more than did P_2O_5 and K_2O applications.

Crude protein content in the forage increased approximately 1.5 percent with each increase in applied N. Crude protein content decreased only slightly through the season until late March. There was about a 1.0 percent difference in protein content of the forage per rate of N at the final harvest. Protein content was at or above the level considered adequate for a beef cow on a grazing program throughout the season, regardless of fertilizer application. Pounds of crude protein per acre increased significantly with increased rates of applied N. The greatest increase in protein production occurred in March; protein production declined most rapidly in April and early May.

Increased N rates resulted in significant decreases in cell wall constituent (CWC) and acid detergent fiber (ADF), and increases in *in vitro* digestible dry matter (DDM). However, these effects were small numerically. It is doubtful whether these small differences could be detected in animal trials. There were highly significant negative correlations of CWC and ADF with DDM. The CWC and ADF had a positive correlation with forage yield, whereas DDM was negatively correlated with forage yield. Pounds DDM per acre increased significantly with increased rates of applied N, but the distribution of DDM production was affected little throughout the season.

Application of N had a negligible effect on P content of the forage. The K content was significantly higher at the 300-pound rate of N than at either the 200- or 400-pound rate. The Ca and Mg contents increased about 0.02 and 0.01 percent, respectively, with increased N rates.

2. Phosphorus

Forage yield increased significantly with increased rates of applied P_2O_5 through 300 pounds per acre. It is doubtful whether the yield increase above 200 pounds of P_2O_5 per acre was economical. The 200- and 300-pound rates of P_2O_5 resulted in higher forage yields in November, December, and April, but lower yields in late January and February, as compared with yields from the 100-pound application.

Crude protein content was not altered by varying rates of applied P_2O_5. Pounds protein increased with increased rates of P_2O_5.

The CWC, ADF, and DDM were not affected by varying rates of applied P_2O_5. The response of DDM per acre to applied P_2O_5 was similar to the response of forage yield to P_2O_5 throughout the growing season.

The P content increased approximately 0.04 percent, as a season average, with each increase in applied P_2O_5. Phosphorus content was higher during midseason than in either the early or late part of the season. There was no significant mean effect of applied P_2O_5 on K content of the forage. The Ca and Mg contents increased about 0.01 percent, as a season average, with each increase in applied P_2O_5.

3. Potassium

Forage yield increased significantly with increased rates of applied K_2O through 300 pounds per acre. The yield increase at the 300-pound rate of K_2O over the 200-pound rate was about one-third the yield increase of the 200-pound rate over the 100-pound rate. Yield distribution was affected by applied K_2O in that yields of the 200- and 300-pound rates were higher than that of the 100-pound rate in December, March, and April, but lower in early November and early February.

Crude protein content in the forage decreased as applied K_2O increased. The magnitude of change decreased as the K_2O increased. The response in pounds crude protein per acre to rates of applied K_2O was essentially the same as the response to applied P_2O_5.

Applied K_2O had no significant effect on CWC or DDM, but did increase ADF significantly at the 200-pound rate over the 100-pound rate. The DDM per acre was higher for the 200- and 300-pound rates over the 100-pound rate throughout the season except in early November, mid-January to early February, and at the end of the season.

The P content in the forage increased by 0.01 percent with 300 pounds of applied K_2O over the two lower rates, averaged over the season. The K content in the forage increased from 2.69 percent to 3.79 percent, as an average, as K_2O rates increased from 100 to 300 pounds per acre. The K content decreased linearly from an average of about 4.5 percent at the beginning of the season to about 2.2 percent at the end of the season. Potassium content in the nonfertilized forage averaged about 0.2 percent higher throughout the season than it did in forage that received 100 pounds of K_2O. There was a greater difference in the K content in forage between the 100- and 200-pound rates of K_2O than between the 200- and 300-pound rates. The Ca and Mg contents decreased similarly with increased rates of applied K_2O. Both minerals increased in concentration in November and March, and decreased in April and May.

4. General Observations

The data indicate that at the 200-pound level of N a 2-1-2 ratio of N-P_2O_5-K_2O, at the 300-pound level of N a 3-2-2 ratio, and at the 400-pound level of N a 4-2-3 ratio generally resulted in near-maximum yields. Increased yield due to the application of all three plant nutrients over yield when one or more of the plant nutrients were omitted justifies the use of a complete fertilizer.

Season had a greater effect on changes in CWC, ADF, and DDM than did the imposed treatments. The CWC and ADF increased in the latter part of the season while DDM decreased proportionately.

Both season and treatments affected the mineral contents in the forage. However, all minerals were at or above the level considered adequate for a beef cow on a grazing program throughout the season. The ratios of the minerals in the forage—P, K, Ca, and Mg—were altered by levels of applied plant nutrients. Consideration should be given to the effects of fertilization on the mineral contents and ratios in the forage when calculating the total ration of ruminants.

There were highly significant year differences for forage yield and all the quality measurements. These were due mainly to amounts and distribution of rainfall and fluctuations in air temperature.

APPENDIX

The analysis of variance is presented in Table 16, and the correlation coefficients in Table 17.

The regression equations used to construct all graphs pertaining to yield and quality measurements are presented in Table 18. Rainfall data are presented in Tables 19-22. The variations in the amount and distribution of rain throughout the seasons and among years are obvious. For example, in September 1967, 4.68 inches fell, whereas for the same month in 1970 only 0.19 inch was recorded. For October in these respective years, 1.45 and 10.57 inches were recorded. Although rainfall data for the first season, 1966-67, were not available, of the four years shown, total rainfall for a season ranged from 48.21 inches in 1968 to 29.04 in 1969-70. November was drier in 1967-68 and 1968-69 than in 1969-70 and 1970-71.

Maximum and minimum air temperature data plotted on 3-day intervals are presented in Figures 15-18. A comparison of the minimum temperatures among years shows that periods of low temperature ranged from late November in 1970-71 to late February in 1967-68.

It is understandable that variations in rainfall and temperature within and among months, and among years, can have measurable effects on forage yield, plant nutrient uptake, and plant utilization of the nutrients. These variations can have temporary effects on the microclimatic conditions in a soil environment which in turn affects crop responses.

Table 16. Analysis of variance on effect of applied N, P, and K on forage yield, quality measurements, and mineral content in forage of an oat-ryegrass mixture, five-year average, factorial treatments

Source	Forage lbs/a	Protein %	Protein lbs/a	CWC %	ADF %	DDM %	DDM lbs/a	P %	K %	Ca %	Mg[1] %
Year	**	**	**	**	**	**	**	**	**	**	**
N	**	**	**	**	**	**	**	**	**	**	**
P	**	NS	**	NS	NS	NS	**	**	NS	*	**
K	**	**	**	NS	**	NS	**	NS	**	**	**
N x P	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	**
N x P	NS	NS	*	NS	*	NS	NS	**	NS	NS	**
P x K	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	*
N x P x K	NS	*	NS	NS	NS	NS	NS	NS	*	*	NS
Clip/Yr.	**	**	**	**	**	**	**	**	**	**	**
N x Clip/Yr.	**	**	**	**	**	**	**	**	*	**	**
P x Clip/Yr.	**	NS	**	NS	NS	NS	**	**	NS	**	NS
K x Clip/Yr.	**	NS	**	NS	NS	NS	**	NS	**	**	**
C.V.	10.0	4.9	11.2	4.1	5.2	1.8	9.9	10.0	11.6	11.1	10.3

1 4 Years only.
NS - Non significant.
* - Significant at .05 level of probability.
** - Significant at .01 level of probability.

Table 17. Correlation coefficients between yield, quality, and mineral measurements in forage of an oat-ryegrass mixture, five-year average, factorial treatments

	Protein %	Protein lbs/a	CWC %	ADF %	DDM %	DDM lbs/a	P %	K %	Ca %	Mg[1] %
Forage yield	-.49**	.80**	.60**	.69**	-.44**	.96**	-.33**	-.42**	.07*	-.01
Protein %		.03	-.75**	-.74**	.54**	-.41**	.44**	.66**	-.02	.34**
Protein lbs/a			.16**	.28**	-.16**	.84**	-.09**	-.09**	.10**	.14**
CWC %				.93**	-.61**	.48**	-.22**	-.50**	.10**	-.03
ADF %					-.65**	.57**	-.26**	-.51**	.14**	-.01
DDM %						.84**	.39**	.43**	.01	.12**
DDM lbs/a							-.25**	-.35**	-.09**	.01
P %								.46**	.02	.36**
K %									-.32**	-.16**
Ca %										.70**

1 - 4 Years only.
* - Significant at .05 level of probability.
** - Significant at .01 level of probability.

Table 18. Regression equations for data illustrated in graphs.

Fig. 1.	200 lbs/a N	$Y=761.72+0.00000028D^4$	$R^2=.27$
	300 lbs/a N	$Y=4525.9+162.10495D-1.73558567D^2+0.00777442D^3-0.00001204D^4$	$R^2=.35$
	400 lbs/a N	$Y=817.81+0.00000038D^4$	$R^2=.38$
	No fertilizer	$Y=342.4807+0.00000017D^4$	$R2=.27$
Fig. 2.	100 lbs/a P2O5	$Y=665.6637+0.00008659D^3$	$R^2=.36$
	200 lbs/a P2O5	$Y=-4402.39+159.2540375D-1.70535054D^2+0.0076187D^3-0.00001175D^4$	$R^2=.32$
	300 lbs/a P_2O_5	$Y=4460.73+160.850715D-1.70308097D^2+0.00749D^3-0.00001135D^4$	$R^2=.32$
Fig. 3.	100 lbs/a K_2O	$Y=760.921+0.00000032D^4$	$R^2=.34$
	200 lbs/a K_2O	$Y=-4466.75+159.4047D-1.695614D^2+0.0075545D^3-0.00001164D^4$	$R^2=.33$
	300 lbs/a K_2O	$Y=-4518.63+164.0491D-1.778838D^2+0.00806857D^3-0.00001265D^4$	$R^2=.33$
Fig. 4.	200-100-100	$Y=465.63718+0.01902554D^2$	$R^2=.37$
	300-100-100	$Y=676.501918+0.00008077D^3$	$R^2=.36$
	300-200-200	$Y=839.1696+0.00000034D^4$	$R^2=.32$
	400-200-200	$Y=833.3784+0.00000039D^4$	$R^2=.36$
Fig. 5.	200 lbs/a N	$Y=33.875-0.0012597D^2+0.00001002D^3-0.00000003D^4$	$R^2=.74$
	300 lbs/a N	$Y=0.95676781+1.0457076D-0.01275266D^2+0.00006322D^3-0.00000011D^4$	$R^2=.71$
	400 lbs/a N	$Y=39.023-0.002566D^2+0.00002237D^3-0.00000006D^4$	$R^2=.69$
	No fertilizer	$Y=29.40375823-0.00031537D^2$	$R^2=.76$
Fig. 6.	200 lbs/a N	$Y=-1138.86+42.290295D-0.46389307D^2+0.002145D^3-0.00000353D^4$	$R^2=.07$
	300 lbs/a N	$Y=-1788.79+63.693123D-0.70578503D^2+0.00328778D^3-0.00000543D^4$	$R^2=.14$
	400 lbs/a N	$Y=-1692.54+62.267007D-0.70222715D^2+0.0033256D^3-0.00000555D^4$	$R^2=.18$
Fig. 7.	DDM% 200 lbs/a N	$Y=129.311-0.9654988D+0.0074234D^2-0.00001796D^3$	$R^2=.26$
	300 lbs/a N	$Y=129.883-0.99721899D+0.00769874D^2-0.00001854D^3$	$R^2=.25$
	400 lbs/a N	$Y=123.402-0.85030631D+0.00672225D^2-0.00001649D^3$	$R^2=.23$
	No fertilizer	$Y=92.931334-0.0000001D^4$	$R^2=.23$
	CWC% Av. over all levels of N, P_2O_5, K_2O	$Y=-47.4350924+2.38711178D-0.02312469D^2+0.00009023D^3-0.00000012D^4$	$R^2=.81$
	ADF% Av. over all levels of N, P_2O_5, K_2O	$Y=-22.31205018+1.15086433D-0.01104349D^2+0.00004242D^3-0.00000005D^4$	$R^2=.75$

Table 18. (Continued)

Fig. 8.	200 lbs/a N	$Y=576.333476+0.01207596D^2$	$R^2=.21$
	300 lbs/a N	$Y=-3718.46+136.79506D-1.50127475D^2+0.00696398D^3-0.0001129D^4$	$R^2=.31$
	400 lbs/a N	$Y=702.631+0.00006686D^3$	$R^2=.33$
	No fertilizer	$Y=305.2246+0.00002781D^3$	$R^2=.19$
Fig. 9.	100 lbs/a P2O5	$Y=529.5605+0.000179D^3-0.00000048D^4$	$R^2=.32$
	200 lbs/a P_2O_5	$Y=-3382.43+126.35126D-1.37962229D^2+0.00636155D^3-0.00001024D^4$	$R^2=.27$
	300 lbs/a P_2O_5	$Y=-3678.52+136.3473123D-1.48032197D^2+0.00675201D^3-0.00001075D^4$	$R^2=.26$
Fig. 10.	100 lbs/a K_2O	$Y=666.3784+0.00005269D^3$	$R^2=.28$
	200 lbs/a K_2O	$Y=3391.54+125.3697D-1.36136835D^2+0.00626717D^3-0.00001008D^4$	$R^2=.29$
	300 lbs/a K_2O	$Y=-3470.2+130.4278D-1.4464624D^2+0.00678411D^3-0.0000111D^4$	$R^2=.29$
Fig. 11.	100 lbs/a P_2O_5	$Y=0.24513421+0.00003083D^2-0.00000023D^3+0.000000001D^4$	$R^2=.08$
	200 lbs/a P_2O_5	$Y=0.19858055+0.0032184D-0.00001092D^2$	$R^2=.13$
	300 lbs/a P_2O_5	$Y=0.315275+0.00153911D-0.00000002D^3$	$R^2=.14$
Fig. 12.	100 lbs/a K_2O	$Y=4.47949038-0.01099618D$	$R^2=.51$
	200 lbs/a K_2O	$Y=5.61077733-0.00036393D^2+0.00000273D^3-0.00000001D^4$	$R^2=.52$
	300 lbs/a K_2O	$Y=6.06633567-0.00041942D^2+0.00000327D^3-0.00000001D^4$	$R^2=.48$
	No fertilizer	$Y=4.65261014-0.0104998D$	$R^2=.24$
Fig. 13	100 lbs/a K_2O	$Y=1.50331996+0.05691455D-0.00060238D^2+0.0000027D^3-0.0000001D^4$	$R^2=.18$
	200 lbs/a K_2O	$Y=1.11275744+0.04292282D-0.00044456D^2+0.00000196D^3-0.00000001D^4$	$R^2=.12$
	300 lbs/a K_2O	$Y=-0.80293568+0.03360702D-0.0003523D^2+0.00000157D^3-0.000000001D^4$	$R^2=.13$
Fig. 14	100 lbs/a K_2O	$Y=1.16589934+0.04218306D-0.00043093D^2+0.00000187D^3-0.00000001D^4$	$R^2=.15$
	200 lbs/a K_2O	$Y=0.69325405+0.0261884D-0.000257D^2+0.00000108D^3-0.00000001D^4$	$R^2=.11$
	300 lbs/a K_2O	$Y=0.5758306+0.02287926D-0.00022877D^2+0.00000098D^3-0.00000001D^4$	$Y=.10$
	No fertilizer	$Y=0.16386702+0.00003321D^2-0.00000003D^3+0.000000001D^4$	$R^2=.61$

Table 19. Rainfall, 1967-68 oat-ryegrass growing season, Franklinton, Louisiana.

Day	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
1			0.53		2.19	0.35		0.05	
2				0.93		0.07	0.17		
3			0.10				0.08		
4					0.29			1.38	
5	0.35						0.05	0.08	
6	1.92						0.39		
7								0.01	
8	0.08	0.05			0.01			0.05	
9	0.07			2.70	0.58		0.02	0.14	
10	1.22			0.97			0.13		0.01
11				0.05			0.13		0.10
12	0.25								.01
13								0.38	
14								0.01	
15				0.31		0.41			
16		0.15							
17				0.02		0.31			0.72
18				1.23		0.55			
19				0.01					
20				0.04					
21				0.80			0.47		
22				1.33		0.12	1.0		
23					.07	0.15	0.2	0.03	
24		0.02						0.10	0.46
25									
26									0.09
27	0.79			1.08		1.23			
28								0.55	
29								0.56	
30		1.20		0.33					
31		0.03		0.07					
Monthly totals	4.68	1.45	0.63	9.87	3.14	3.19	2.64	3.34	1.39
Season total	30.33								

Table 20. Rainfall, 1968-69 oat-ryegrass growing season, Franklinton, Louisiana.

Day	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
1				1.94		0.07			
2						0.79			
3	0.01		0.28	0.84	0.11		0.08		
4	0.07	0.14							0.13
5	0.45	0.03				0.05		1.81	0.92
6		0.03	0.64	0.15		0.29	1.05		
7				0.03					1.33
8		0.05	0.65				0.04		1.39
9		0.06	0.45					0.01	
10			0.45					1.24	
11			1.24						
12								0.10	
13				1.60		0.04		2.70	0.05
14						1.18		1.60	0.08
15	0.77		0.34			0.05	0.91		
16			1.27		0.09		0.37	0.26	0.21
17	2.00				0.09		1.82	0.74	0.89
18				0.04	0.14		0.13	0.26	0.13
19				0.55	0.08				
20						0.02			
21				2.30	0.12	1.43			
22				0.30	0.01	0.48			
23							2.11		
24		0.22							1.95
25	0.04								0.32
26	0.06			0.04					0.02
27			0.11	0.30					
28			0.29		0.06	0.13			
29			0.04						
30			1.03	1.45	0.07				
31									
Monthly totals	3.40	0.53	6.79	9.54	0.77	4.53	6.51	8.72	7.42
Season total	48.21								

Table 21. Rainfall, 1969-70 oat-ryegrass growing season, Franklinton, Louisiana.

Day	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
1						1.52		0.30	0.02
2							0.02	0.08	2.24
3							0.05		0.90
4	0.26								
5		0.01		0.38	1.11				
6		0.10		1.21	0.49		0.26		
7		2.05	0.02						
8		0.45				0.04			
9				0.81					
10				0.07	0.07			0.30	
11					0.84		0.52	0.85	
12									
13		0.40	0.99				0.01		
14					0.01				
15						0.35		0.50	
16						0.39			0.63
17							0.92		0.25
18			1.75				0.03		
19		0.02	0.12		0.10		0.28	0.44	
20	0.10						0.09		
21				0.80			0.55		
22									
23				0.03	0.02				
24						0.43			
25				0.13	0.02	0.32			0.11
26					0.20		0.13		
27									
28				0.03	0.01		0.04		0.25
29					0.14				1.44
30		0.02		0.70					
31		0.08					1.13		0.13
Monthly totals	0.36	3.13	2.88	4.16	2.99	3.05	4.03	2.47	5.97
Season total	29.04								

Table 22. Rainfall, 1970-71 oat-ryegrass growing season, Franklinton, Louisiana.

Day	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
1							0.30	0.24	
2	0.20						0.75	0.07	
3	0.03						0.03		
4					0.32	0.77			
5									
6		0.57				0.18	0.54		
7		2.80			0.05	1.05			0.33
8	0.02				0.37	0.04			0.86
9		1.29	0.73						
10				0.16	0.21				
11				1.29		1.20			0.86
12		3.11							0.40
13		1.30	1.48						
14					0.16				
15	0.37			2.00			0.22		
16	0.04							0.20	
17								0.08	
18		0.08					1.05		
19		0.12				0.23			
20						0.54		0.50	0.12
21						0.38	0.03		
22									
23	0.03	0.09		0.58	1.90		0.10	0.10	
24		0.34		0.04					0.07
25				0.07					
26						0.75	0.08		
27		0.77							0.14
28		0.10							
29				1.68			1.14		
30				1.08					
31									
Monthly totals	0.19	10.57	2.21	6.90	3.01	5.14	4.51	1.19	2.78
Season total	36.50								

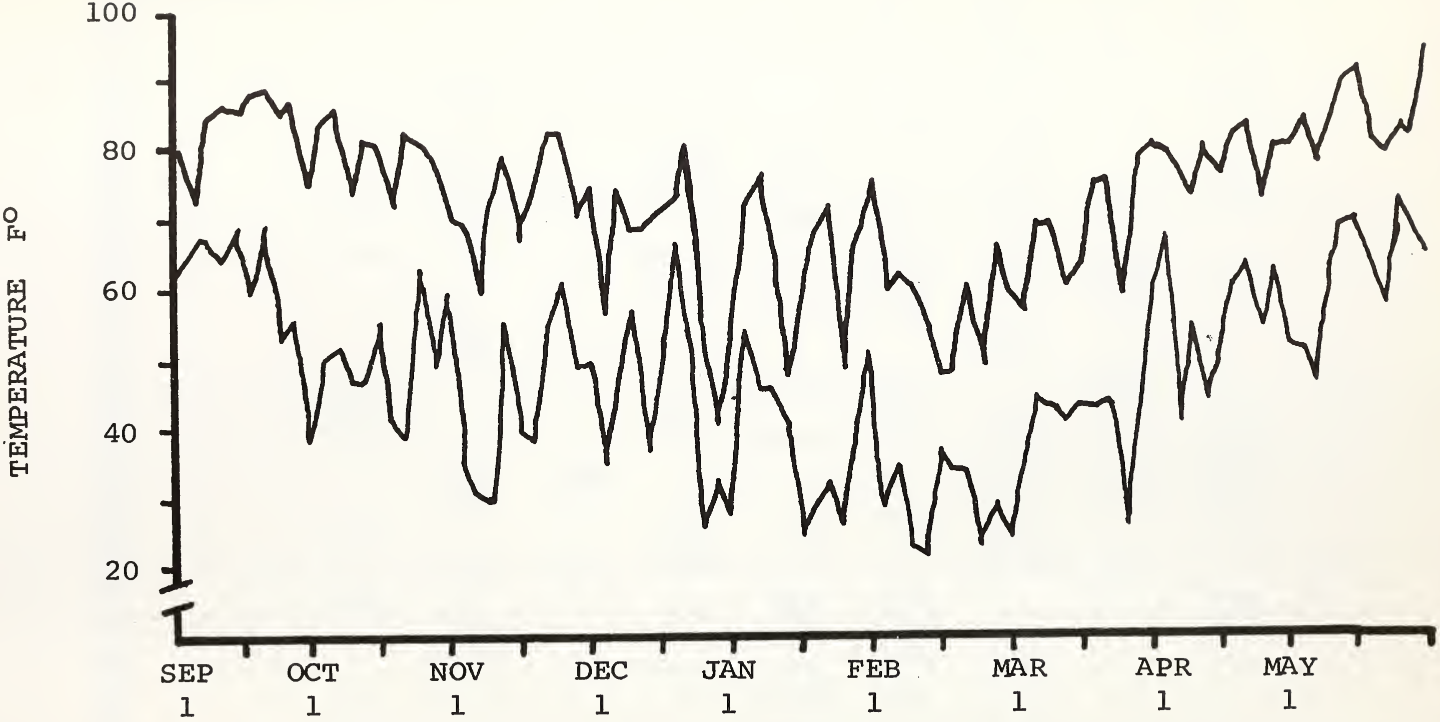

Fig. 15. Maximum and minimum air temperatures plotted on 3-day intervals through 1967-68 oat-ryegrass growing season, Franklinton, Louisiana.

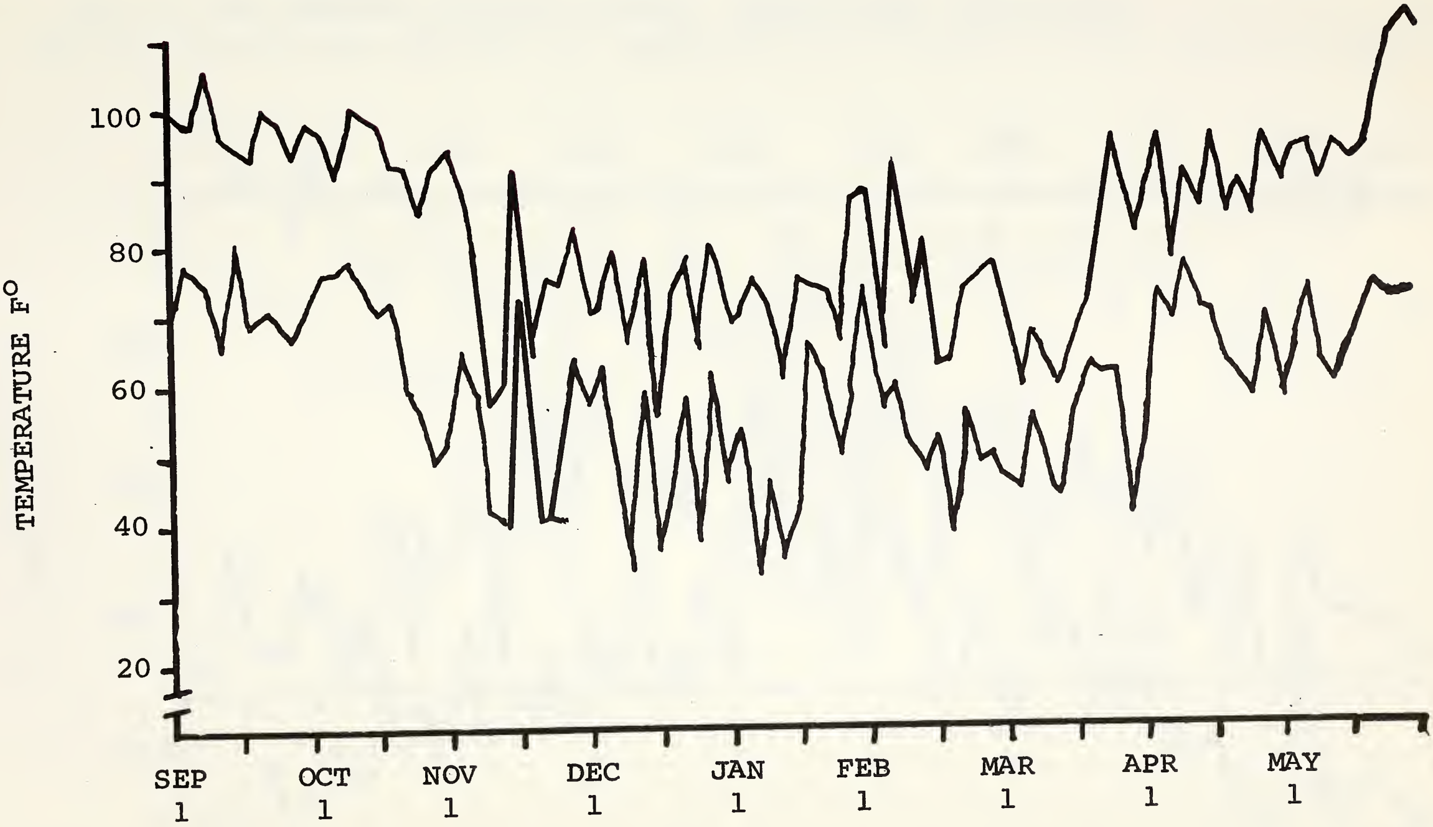

Fig. 16. Maximum and minimum air temperatures plotted on 3-day intervals through 1968-69 oat-ryegrass growing season, Franklinton, Louisiana.

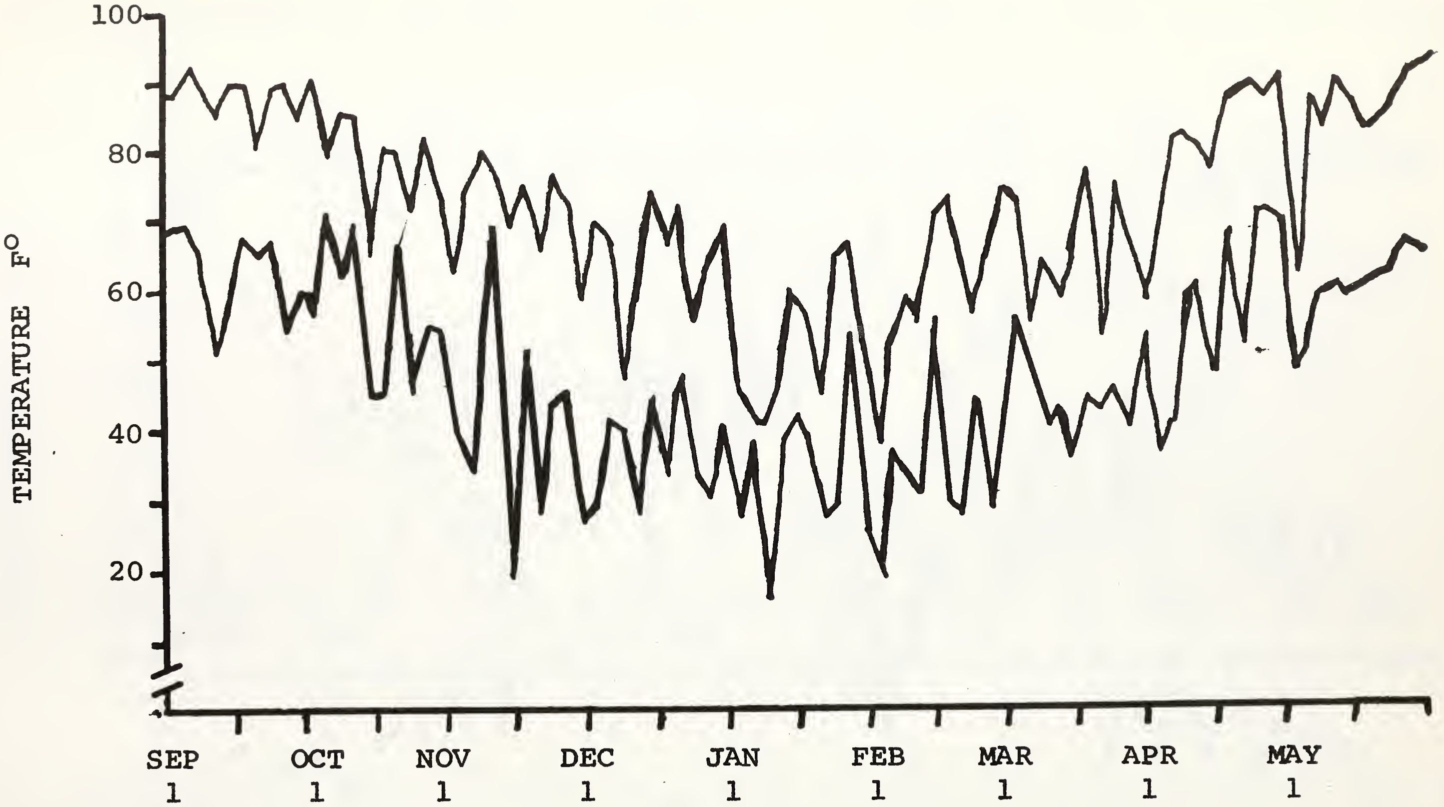

Fig. 17. Maximum and minimum air temperatures plotted on 3-day intervals through 1969-70 oat-ryegrass growing season, Franklinton, Louisiana.

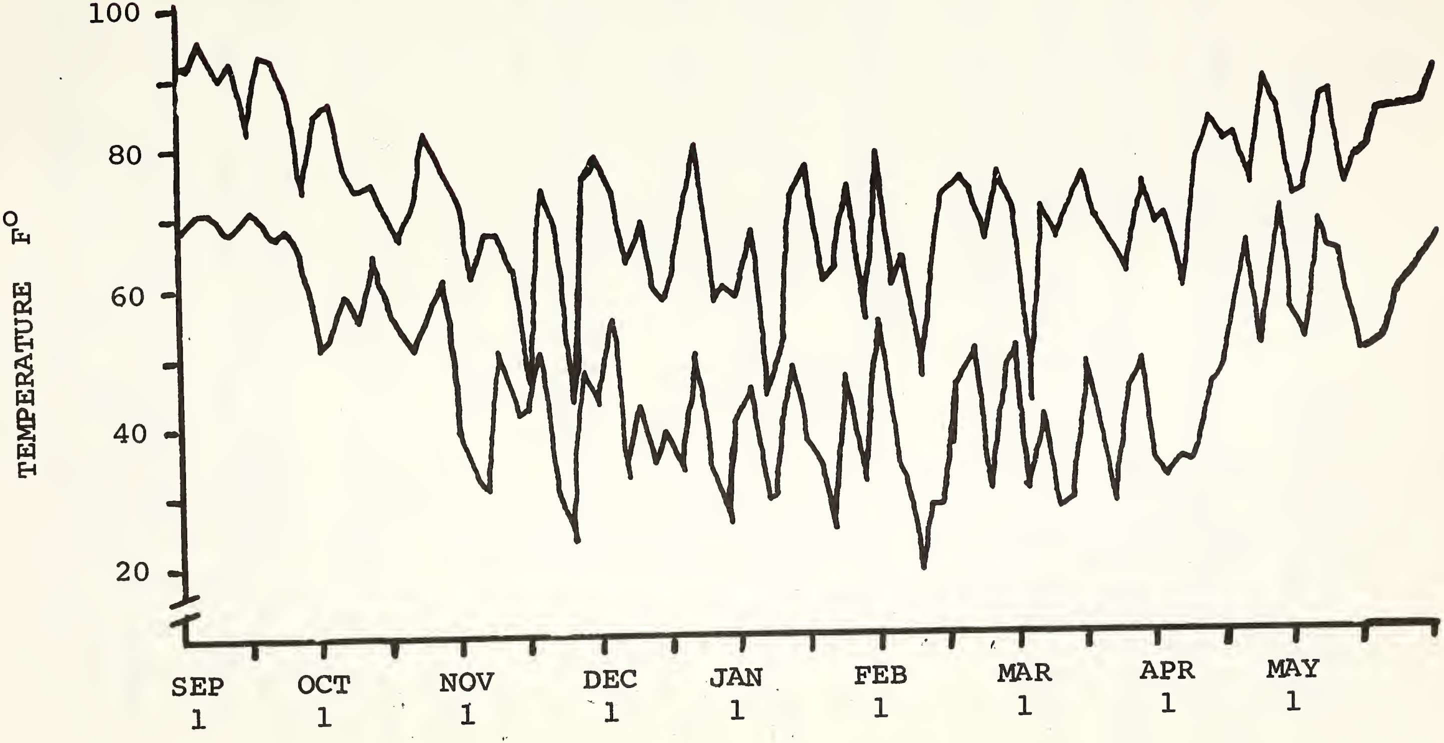

Fig. 18. Maximum and minimum air temperatures plotted on 3-day intervals through 1970-71 oat-ryegrass growing season, Franklinton, Louisiana.

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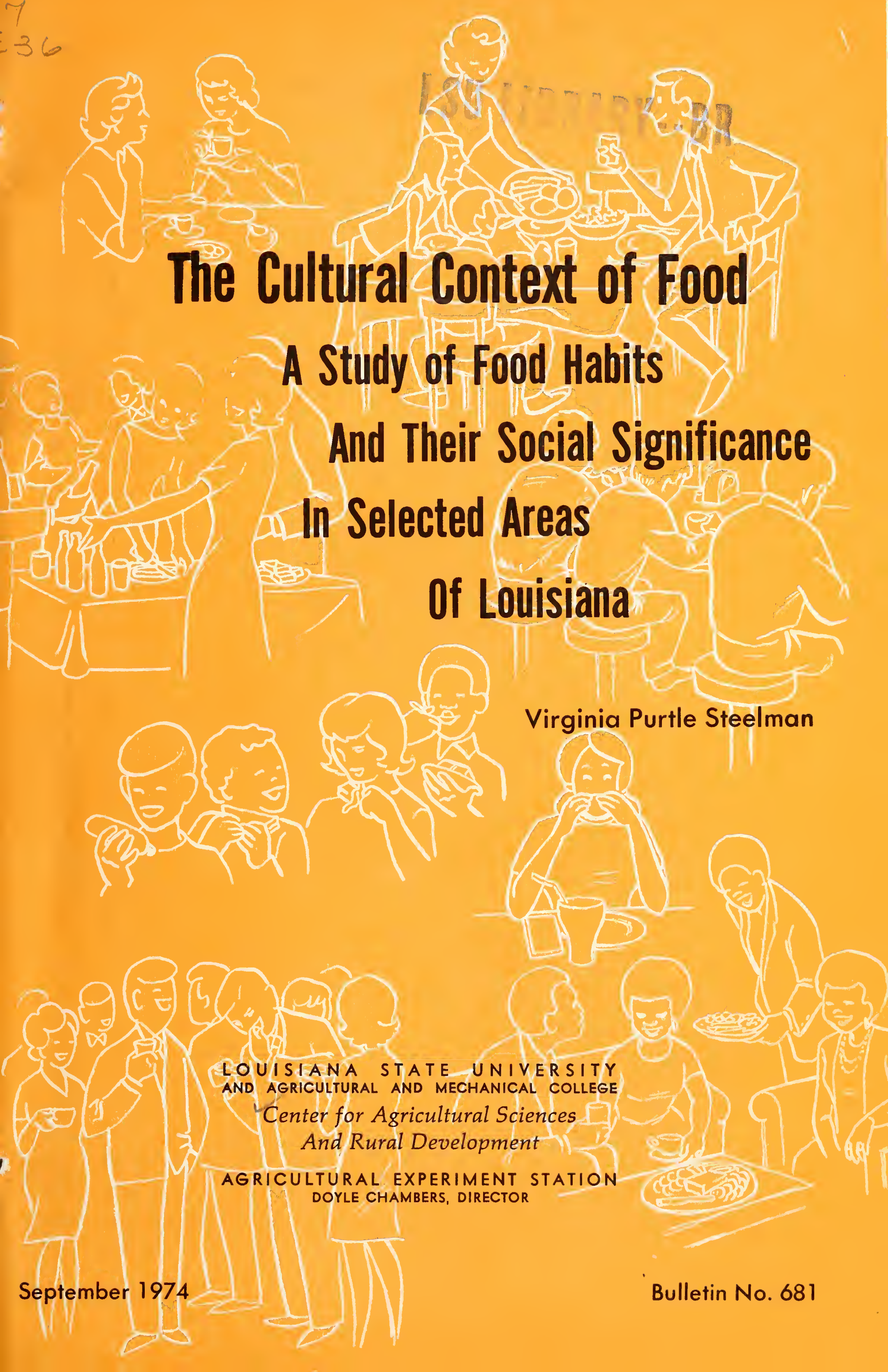

The Cultural Context of Food

A Study of Food Habits And Their Social Significance In Selected Areas Of Louisiana

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The Cultural Context of Food

A Study of Food Habits and Their Social Significance In Selected Areas of Louisiana

VIRGINIA PURTLE STEELMAN[1]

Introduction

The past 20 years have witnessed great advances in knowledge about nutrition and food technology. In spite of this progress, the nutritional adequacy of the average American diet has decreased during this time, or at best has not improved. Surveys conducted by the U.S. Department of Agriculture, beginning in 1936, reveal that families throughout the nation steadily improved their diets until sometime after 1955. However, the next decennial survey, conducted in 1965, revealed an adverse trend in the nutritional adequacy of family diets (USDA-ARS, Household Food Consumption Survey, 1965-66, Report No. 6).

Many factors apparently contribute to inadequate diet and consequent nutrition problems. Probably the most frequently cited is poverty. Nutritional surveys in low income areas of Louisiana and Texas revealed that malnutrition was as prevalent in those areas as in many remote countries of Central America, Asia, and Africa (*Nutrition Today*, 1969, p. 7).

The 1965 USDA survey showed only 37 percent of those families with an annual income of $3,000 or less, the poverty level, had adequate diets. However, the presence of factors other than income is evidenced by the fact that families with high incomes often have inadequate diets. Only 63 percent of the families with annual incomes over $10,000 had diets which were classified as good in the 1965 survey. Findings such as these are cause for concern and provide a rationale for research such as that conducted in this study.

A lack of knowledge on the part of the public may be partially responsible for poor diets and resultant nutritional deficiencies. However, many educational attempts have been made through the news media, home economics and science classes, and the Cooperative Extension Service programs of land-grant universities to make nutrition information available. Because of the difficulty of putting the nutrition message across, it has been recognized that social and cultural factors play an important role in food attitudes and habits. However, little research has been done in this area. John Cassel (1957, p. 732) listed two major reasons for the ineffective application of social science research findings to programs conducted by nutritionists trained in biological science:

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> The first is the lack of effective communication between the two sciences; the second, the degree to which we as health workers are "culture bound" and tend to reject concepts and patterns of behavior different from our own.

Consistent with this theme, Cassel (1957, p. 739) also pointed out the significance of considering subcultural differences in planning educational programs:

> It should be appreciated that while it is permissible for some purposes to consider an over-all "American Culture," numerous distinct subcultures exist sometimes even within a single county. These subcultural groups must be carefully defined, as programs based on premises, true for one group, will not necessarily be successful in a neighboring group.

Margaret Mead (1943, p. 136) recognized the need to study the meaning attached to food from the subcultural perspective at a much earlier date.

> So while it is necessary, in order to inaugurate long-time nutritional changes in the diet, for instance of Green County, Georgia, to know the concrete details of the diet here, it is also necessary to know in what terms the inhabitants of Green County view their diet, how changes may be phrased so that they will be accepted and welcomed, what phrasings should be avoided because they will awaken anxiety, mere temporary compliance, or actual resistance.

With regard to cultural conditioning, a factor often overlooked in nutrition education programs is the difference in the meaning attached to certain foods by various groups. As pointed out by Kretch, et al., (1962, p. 279) words have two types of meaning: denotative and connotative.

> Denotation is the explicit identification of the referent. . . . Connotative meaning refers to the wider penumbra of ideas and feelings and action tendencies which cluster about a word, to the attitudinal components of the meaning.

As recognized by Mead, the connotative meaning of specific food items varies by subculture. For example, for many Southern adults the words "fried chicken" bring to mind childhood Sunday dinners with friends and relatives or the preacher. "Mother," "good times," "friends" may all be subconsciously or consciously associated with the term and just to think of "fried chicken" may make a person feel good. To children today, the same word may mean a family outing to "Colonel Sanders'," or that mother is too busy to cook tonight, although some children of the current generation will undoubtedly have feelings toward fried chicken similar to those of their parents. Whatever connotative meaning a Southerner attaches to fried chicken, one can be sure it is more than poultry flesh coated with some type of batter and cooked in hot grease. Cultural meanings attached to food have a definite bearing on whether or not an item is accepted by a given group of people. It was the thesis of this study that these meanings must be taken into account if nutrition education programs are to be effective.

Not only do the meanings attached to food items vary by subculture, but the members of subcultures also vary with regard to when they eat what. In other words, little breakfast, if any, a large noon meal and a light night meal may be typical of one group as compared with a light breakfast, a light noon meal and a heavy night meal by another group. Although it is not yet known what effect, if any, the distribution of equal amounts of food during a day has on nutritional status, it is known that certain foods are more likely to be included at given times of the day. For example, eggs and orange juice are more likely to be eaten in the total "American" culture at the morning meal than at other times of the day. Therefore, persons who skip breakfast may be missing important sources of ascorbic acid from orange juice or other citrus fruit, as well as other nutrients. Differences in meal patterns may, therefore, affect the adequacy of the total diet.

The origin of beliefs and attitudes associated with certain food items within a subculture may be unknown. However, knowledge of these beliefs and attitudes is undoubtedly of value to those interested in upgrading the nutritional quality of diets. The major objective of the research reported here was to demonstrate that food items associated with selected concepts vary by subculture. On the assumption that connotative meanings are associated with specific foods, questions were designed to determine what foods were associated with selected concepts by Black homemakers and White homemakers in two Louisiana communities. Foods actually eaten and meal patterns of the homemakers were also studied.

Methodology

Sample

Homemakers from a systematic random sample of households were interviewed in two Louisiana communities. With the help of Cooperative Extension Service specialists, two towns were selected on the basis of the following criteria: representative of a distinct subculture; a trade center for a surrounding farming area, and a population between 4,000 and 8,000. A household met the sample criteria if a responsible adult female with either a husband or child, or both, resided in the house. Some kind of family relationship was necessary for the woman to be interviewed. One hundred and seventy-nine homemakers in a North Louisiana predominantly Protestant community were successfully interviewed and 182 interviews of homemakers were completed in a South Louisiana predominantly Catholic community. Of the total number, 40 percent were completed for Black respondents in the first community and 29 percent for Black respondents in the latter community. Ninety percent of the respondents in the North Louisiana community reported membership in a Protestant Church and 95 percent of the homemakers in the South Louisiana community sample reported membership in the Catholic Church.

Foods Associated with Selected Concepts

On the assumption that multiple attitudes toward food do exist, open-end questions were formulated to determine what foods were associated with certain concepts in the study communities. Specifically, these concepts were related to tradition (what mother cooked), convenience, frugality, health, social status, and sociability aspects. Questions concerning other food patterns, such as beverage consumption, wild food consumption and superstitions related to food, were also included. Responses to the questions were categorized by the patterns determined to be prevalent in the data. Each question was coded independently of the other questions because of varying response patterns. Categories for a given question were not mutually exclusive in that some responses were appropriately coded in more than one category. For example, spaghetti and meatballs were coded under spaghetti as well as under ground beef, and barbecued steak was coded under both barbecue and steak. Because of this procedure, no statistical analysis could be done on an item between questions or between items for a given question. Also, some food categories were more general than others, such as miscellaneous vegetables versus potatoes. Category decisions, as noted, were based on the frequency of responses.

Frequencies were determined for each response category for respondents grouped according to (1) locality, (2) race, (3) locality by race, and (4) occupational prestige scores. Occupational prestige scores, rated by the N.O.R.C. system (Reiss, 1961), were divided into three groups: low, 0-49; medium, 50-69, and high, 70-99.

Food items mentioned by 15 percent of the total sample or by 15 percent of the respondents in any of the above groups on a given question were designated as being representative of that particular concept. A one-sample, two-tailed chi-quare analysis was applied to data in these categories to determine whether differences in responses by groups were statistically significant. The expected frequencies were based on the percentage of each group in the total sample.

Prevalent Patterns in Actual Food Consumption

All foods reported eaten by a homemaker in the 24 hours prior to the interview were recorded. Method of preparation, time eaten, and quantity eaten were also recorded. Quantities were estimated from graduated food models (Moore, et al., 1967). Each interviewer was given a kit that included models of food such as rice or meat in standardized amounts. The respondent could look at the model and determine the amount she had eaten in relation to the size of the model, such as one-half or two times as much. The models were coded so that the interviewer recorded "½ A" or some other appropriate amount. These values were converted to grams for the calculation of the nutritive value of the diets. The respondents were also asked if the previous day's diet was fairly typical of their normal diet. Actual nutritive values of the reported diets were calculated but are not reported here.

For purposes of this report, the foods eaten by each respondent were treated as responses to open-end questions. Thus, the numbers of persons who reported having eaten a given food were totaled by the subcultural groups of locality, race, and locality by race. One-sample, two-tailed chi-square analyses were applied to the data as explained in the preceding section.

Meal Patterns

Meal patterns of the four subcultural groups included in the study were analyzed by differences in the number of persons in each category who ate a given meal and by the differences in the percentage of the daily intake of calories consumed in each meal. The time of day a food was eaten was recorded along with the food and quantity eaten. Foods consumed were classified in the categories of breakfast, lunch, dinner or snack. If a person had anything more than a cup of coffee and cookies before 10 a.m., it was considered a breakfast. Typical breakfast foods (eggs, bacon, toast) eaten as the first food of the day and before noon were also considered as breakfast. The most food eaten at a given time between 10 a.m. and 3 p.m., if two or more items with nutritive value other than calories were included, was classified as lunch. Two or more foods with nutritive value that were eaten after 3 p.m. were classified as dinner. All other foods not in typical meal patterns were classified as snacks. Some arbitrary decisions had to be made, such as classifying a soft drink and potato chips as a snack rather than lunch when eaten at noon time and no other meal was eaten in the lunch time period. A sandwich and a coke were classified as lunch if eaten between 10 a.m. and 3 p.m. and if no other obvious complete meal was eaten during that time. However, a sandwich and a coke eaten at 2:45 p.m. after an obvious noon meal were classified as a snack. Cabbage and cornbread eaten at 7 a.m. were categorized as breakfast. All decisions concerning meal patterns were made by considering the total day's pattern.

Results and Discussion

Foods Associated with Selected Concepts

Discussion of the responses to each concept question will include the question and the rationale for including it in the study. Tables which include the response categories and the percent of the total sample who answered in each category are presented in this section. Tables are included in the Appendix which give the statistically significant chi-square analyses with the expected and observed frequencies of each group included in the analysis.

Tradition: Foods Prepared by Mothers—It is known that food habits, as other cultural patterns, are transmitted from one generation to the next and that certain items are retained to a greater extent than others. Foods prepared by the respondents which could be identified as ones their mothers or their husbands' mothers prepared were considered as the most traditional food items in the diets of the respondents. These foods are often thought of in nostalgic terms and are the ones most entrenched in the subculture.

The respondents were asked two questions which were related to the continuity of food habits from one generation to the next. These were: "What foods did you eat as a child that you still prepare?" and "What foods, if any, do you prepare that your husband's mother cooked?" The percentages of respondents in the total sample who answered within given food categories are shown in Tables 1 and 2.

Table 1.—Percent of respondents preparing certain food items which their mothers prepared

Food item	% of total sample	Food item	% of total sample
Miscellaneous vegetables	24.7	Beef	9.7
Chicken	19.9	Pork	8.6
Everything	17.7	Biscuits	6.9
Dry beans and peas	16.1	Sweets	6.4
Cornbread and cush-cush	15.5	Stews	4.7
Potatoes	13.3	Ground beef	3.9
Greens	11.9	Seafood, fish and crayfish	3.9
Rice	10.8	Macaroni and spaghetti	2.5
		Miscellaneous	8.6

Table 2.—Percent of respondents who listed certain food items now prepared which their husbands' mothers prepared

Food item	% of total sample	Food item	% of total sample
Miscellaneous vegetables and fruits	16.9	Pork	5.3
Chicken	12.2	Beef	5.0
Dry beans and peas	10.8	Sweets	5.0
Rice	9.4	Biscuits	5.0
Stews, gumbo, soup	7.2	Greens	4.4
Cornbread and cush-cush	7.2	Ground beef	3.3
Seafood, fish and crayfish	6.9	Spaghetti and macaroni	2.8
		Miscellaneous	6.1
		Everything	5.5

Given food items listed by at least 15 percent of any group as foods prepared by the respondents that they remembered from their childhoods and that differed significantly by analysis groups are shown in the following outline with the subgroup that had the highest response rate for each item. Food items reported at similar rates by all groups were miscellaneous vegetables and cornbread.

Differences by locality	**Food item**
North Louisiana	Chicken Greens Dry beans and peas Sweets
South Louisiana	Rice
Differences by race	
Whites	Chicken Beef Rice Potatoes
Blacks	Pork Greens
Differences by locality by race	
North Louisiana Whites	Chicken Beef
South Louisiana Whites	Rice
North Louisiana Blacks	Pork Greens Dry beans and peas
South Louisiana Blacks	None
Differences by occupational prestige	
High	Chicken Everything
Medium	None
Low	None

Items reported as ones the homemakers now prepare that their husbands' mothers prepared are shown in Table 2.

An analysis of the responses to the question concerning items prepared by the husband's mother that the respondent prepared revealed only one statistically significant difference. The South Louisiana Whites reported seafood, fish and crayfish at significantly greater rates than did the other three analysis groups.

If total number of responses can be used as an indicator, one can assume that respondents in this sample consciously carried on the food patterns of their own childhood more than they did those of their husbands. It is probable that in many cases the childhood patterns of each homemaker and her husband were similar, but as might be expected the respondents seemed to identify with their own childhood food habits more than with those of their husbands.

The food categories mentioned most often by the South Louisiana Blacks who had no distinct patterns of their own were similar to those of either the North Louisiana Blacks or the South Louisiana Whites.

It appears that persons from the South Louisiana community have prepared foods in a similar manner for generations. If this is true, the items most remembered by individual respondents were so diverse that distinct patterns failed to appear from their responses. However, findings from related research indicate that, of the four subcultural groups, South Louisiana White respondents were the most likely to change food habits (Steelman, 1972). Even in the "everything" category the difference between responses in the two communities was not significant.

Respondents in the groups with high occupational prestige scores gave "everything" as an answer at significantly greater rates than did the other respondents. This suggests that these persons are more tradition oriented. It is likely that they had more desirable diets as children and, therefore, have less reason to change them than do respondents in the two lower occupational prestige groups.

Convenience: Foods Prepared When in a Hurry—The concept of convenience or efficiency seems to be an important one in our society. Robin Williams (1970, p. 467) listed "Efficiency and Practicality" as one of the American Value Systems and one trip to a supermarket reveals that this value penetrates the behavior arena of food selection and preparation. It is known that certain food items require less preparation time than others, but some of the so-called "convenience foods" are considered undesirable by certain persons; therefore, items which are considered convenience foods by particular groups may be rejected by other groups. In fact, the words "convenience food" may be so emotionally laden to some people that they will respond that they do not like convenience foods at one and the same moment that they are eating canned peas.

The respondents were asked one question related to convenience foods which did not include the word "convenience." This question was, "What foods do you prepare when you are in a hurry?" The percentages of respondents in the total sample who answered within given food categories are presented in Table 3.

Table 3.—Percent of respondents who listed certain food items as food they prepare when they are in a hurry

Food item	% of total sample	Food item	% of total sample
Sandwich	31.6	Canned	9.1
Hamburgers and hot dogs	23.6	Frozen	8.0
Casserole and spaghetti	15.5	Salad	7.8
Steak	11.6	Soup	7.2
Bacon and Eggs	11.1	Fried	3.6
		Miscellaneous	26.3

All groups reported the following items at the same rates: casseroles and spaghetti; steak, and bacon and eggs. Food items which were listed as "convenience" foods by 15 percent of any study group and at significantly different rates are given in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food item**
North Louisiana	Sandwiches
South Louisiana	None
Differences by race	
Whites	Hamburgers and weiners
Blacks	None
Differences by locality by race	
North Louisiana Whites	Sandwiches
South Louisiana Whites	Hamburgers
North Louisiana Blacks	None
South Louisiana Blacks	None
Differences by occupational prestige	
High	None
Medium	None
Low	None

Major differences between groups were in the categories of sandwiches and hamburgers and weiners. The North Louisiana Whites had the highest response ratio for sandwiches and the South Louisiana Whites responded least often of the four groups that they made sandwiches when in a hurry. The high response rate of hamburgers by the South Louisiana Whites suggests that even when rushed they may spend more time in food preparation than do the North Louisiana Whites. These findings also suggest that sandwiches are considered less desirable food items by the South Louisiana Whites than by the other three subcultural groups.

Cost of Food: Expensive and Inexpensive Foods*—It was suspected that food items viewed as most expensive or most inexpensive by homemakers would not necessarily be the extremes available to them. It was believed that items which are considered expensive or inexpensive actually reflect the cost range within the desired diet patterns of a given group. In addition, many homemakers probably do not determine the value by cost per serving; therefore, their conception of cost would be inaccurate.

The following questions were designed to determine which foods were associated with extremes of cost: "What foods do you think are very expensive?" and "What would you serve if you were planning a very inexpensive meal?" The percentages of respondents whose answers fell within given food categories are presented in Tables 4 and 5. As might be expected, all groups of respondents listed meat as an expensive food at about equal rates.

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*The data for this project were collected prior to government control of food prices. Responses would possibly differ on a current sample.

Table 4.—Percent of respondents who listed certain food items as expensive food

Food item	% of total sample	Food item	% of total sample
Beef	37.7	Pork	18.8
Steak	34.4	Seafood and crayfish	12.2
Vegetables and fruits	21.9	Chicken	3.6
Meat	20.2	Other	11.9

Table 5.—Percent of respondents who listed certain food items as inexpensive food

Food item	% of total sample	Food item	% of total sample
Chicken	40.2	Stew, soup, chili, etc.	13.9
Local vegetables and fruits	35.5	Cornbread	13.9
Ground meat	27.2	Eggs	11.9
Rice	20.8	Fish and tuna	5.8
Dry beans and peas	20.5	Beef roast	4.2
Potatoes	17.5	Sandwiches	1.9
		Miscellaneous	18.3

Food items which were mentioned by 15 percent of any group in the study as expensive foods at significantly different rates from the other groups are given in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food item**
North Louisiana	Seafood Vegetables and fruits Steak
South Louisiana	Beef
Differences by race	
Whites	None
Blacks	Pork
Differences by locality by race	
North Louisiana Whites	Seafood Vegetables and fruits
South Louisiana Whites	None
North Louisiana Blacks	Pork Steak
South Lousiana Blacks	None
Differences by occupational prestige	
High	None
Medium	None
Low	Pork

All groups listed dry beans and peas as inexpensive foods at similar rates. Food items which differed in response rates and which were considered inexpensive by 15 percent of any group in the analyses are given in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food item**
North Louisiana	Spaghetti and macaroni Local vegetables and fruit Cornbread
South Louisiana	Rice

Differences by race

Whites	Ground beef Eggs Stew, soup, gumbo
Blacks	None

Differences by locality by race

North Louisiana Whites	Ground beef Spaghetti and macaroni
South Louisiana Whites	None
North Louisiana Blacks	Local fruits and vegetables
South Louisiana Blacks	Rice

Differences by occupational prestige

High	Ground beef
Medium	None
Low	Chicken

In the expensive food categories, the general category of beef was mentioned more by the South Louisiana respondents; however, steak was listed by relatively more North Louisiana respondents. As will be seen later, steak is a popular food in the North Louisiana community. The North Louisiana Whites eat seafood at a great enough rate to be concerned with the cost, where the North Louisiana Blacks eat little seafood and, therefore, have little reason to be concerned with the cost. Due to the greater access to seafood in the South Louisiana community, the costs are more moderate; therefore, there is less reason for the South Louisiana respondents to be concerned with the cost of seafood.

Pork, a food item mentioned by Black respondents as food their mothers prepared that they prepare, was also listed as an expensive food by the Blacks. The high ratio of low occupational prestige respondents who mentioned pork was due mainly to race differences.

Chicken, mentioned by 40.2 percent of the respondents as an inexpensive food, had an interesting response pattern in the analysis by occupational prestige. Approximately 53 percent of the low occupational prestige respondents mentioned chicken as an inexpensive food, whereas only 33 percent of the middle group of respondents gave chicken as an answer to the question about inexpensive food. The percentage of high occupational prestige respondents for this category was between that of the other two groups—39 percent. This response pattern may be a case of low occupational prestige respondents having an inaccurate conception of the actual cost per ounce of edible portion of chicken. Homemakers in the middle occupational prestige group may be more aware of the real cost and, therefore, view it as being more expensive than some other items in their diet. Respondents in the high occupational prestige group probably are aware of the real cost and still view it as inexpensive as compared with other meats they purchase.

Rice is an example of a food that is relatively inexpensive, but one that is more frequently consumed by certain subcultural groups than by others. The North Louisiana Whites, who apparently eat less rice than the other three subcultural groups included in this study, mentioned rice as an inexpensive item least often of the four groups. The South Louisiana Black respondents, who frequently served rice, mentioned this item most frequently of the remaining three groups as an inexpensive food. This is an example of how dietary choices influence one's conception of food costs more than does the total range of food available.

Social Status: Foods Served to Impress Others and Undesirable Foods—Several investigators (Lewin, 1943; Cussler and de Give, 1943; Bennett, Smith, and Passin, 1942) have recognized that social distinctions are made between various foods. An individual might aspire to eat gourmet-type foods even though he cannot afford them and at the same time he might consider some other food as unacceptable for status reasons. These distinctions are known to vary by subcultural groups.

For purposes of this study, foods were divided into three status levels: high, low, and unacceptable. As with certain other terms, such as "convenience," the word "status" was avoided in the actual questions because of emotional connotations attached to the word. Three questions related to status levels were asked. The question "What foods would you serve someone you really wanted to impress?" was aimed at determining the foods accorded the highest status by respondents. "What foods, if any, does your family eat that you would rather not serve to guests?" was designed to determine if a low status level of foods existed. The third question, "What foods, if any, do you consider as not good enough for your family?" was aimed at determining which foods were considered unacceptable by respondents.

The percentages of respondents who mentioned given food items in response to these three questions are presented in Tables 6, 7, and 8.

Table 6.—Percent of respondents who listed certain food items as foods they would serve to impress someone

Food item	% of total sample	Food item	% of total sample
Steak	25.5	Crayfish	11.1
Miscellaneous vegetables	23.6	Pork roast and ham	10.8
Salad	22.7	Miscellaneous	9.1
Beef roast	22.4	Breads	6.9
Chicken	20.5	Seafood and fish	6.1
Potatoes	19.1	Barbecue	4.4
Rice	16.9	Macaroni and spaghetti	3.3
Sweets	12.7	Soups	2.2

Table 7.—Percent of respondents who listed certain food items as food not good enough to serve guests

Food item	% of total sample	Food item	% of total sample
Ground beef and weiners	8.6	Organ and boney meats	2.2
Beans	5.8	Greens	2.2
Cornbread and cush-cush	4.7	Sandwiches	1.9
Miscellaneous meats	3.6	Miscellaneous vegetables	1.7
Fish	3.3	Chicken	1.7
Soups	2.8	Miscellaneous	5.8

Table 8.—Percent of respondents who listed certain food items as unacceptable

Food item	% of total sample	Food item	% of total sample
Cheap cuts and organ meats	8.9	Miscellaneous vegetables	3.3
Wild foods	6.9	Pork	2.5
		Miscellaneous	8.0

All groups seemed to identify salads, chicken, potatoes, and miscellaneous vegetables as foods they would serve to impress someone. Food items which were listed as high status foods at greater rates by certain groups are given in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	Food items
North Louisiana	Steak Sweets
South Louisiana	Beef roast Rice Crayfish

Differences by race	
Whites	Beef roast
Blacks	Rice
Differences by locality by race	
North Louisiana Whites	Steak Sweets
South Louisiana Whites	Beef roast Crayfish
North Louisiana Blacks	None
South Louisiana Blacks	Rice
Differences by occupational prestige	
High	None
Medium	None
Low	None

Items in only one food category (ground beef and weiners) were mentioned as low status foods by 15 percent of any group of respondents. Analyses were done on the total number of responses to determine if any group or groups mentioned low status food items at a significantly greater rate than the other groups. Food items that were significantly different between the study groups are given in the following outline.

Locality	**Food item**
North Louisiana	Total of all responses
Locality by race	
North Louisiana Whites	Ground beef and weiners
All other groups	None

No food items were mentioned by 15 percent of the respondents of any group in response to the question concerning unacceptable foods ("What foods, if any, do you consider as not good enough for your family?"). However, North Louisiana homemakers gave significantly more responses to the question that did South Louisiana homemakers, indicating a greater concern on their part with unacceptable foods.

In this study, high status foods were more readily identifiable than low status items. High status items, in our society, are generally the rarest or most expensive. Therefore, it could be expected that items mentioned as high status foods would be similar to those listed as expensive foods. Two items identified as high status foods—steak and roast beef—were, in fact, two that were most often mentioned as expensive foods. However, chicken, potatoes, and rice, which received high response rates as inexpensive foods, were also listed as high status foods. The high status accorded chicken may be due to a cultural lag from a time when chicken was a more scarce and expensive item. Potatoes or rice are often served with meat; therefore, they may be considered high status accompaniments.

North Louisiana respondents mentioned steak as a high status food more often than did South Louisiana respondents, and homemakers in the South Louisiana sample listed beef roast more often than did North Louisiana respondents. This finding is consistent with the differences found between groups in the analyses of the responses regarding expensive food.

Respondents in the North Louisiana sample listed more low status and unacceptable food items than did South Louisiana respondents. This finding suggests that the North Louisiana homemakers were more concerned with status differences than were the South Louisiana respondents. Results of related research substantiate this finding (Steelman, 1972).

Sociability: Foods Served to Good Friends—Some foods are served to impress guests, while others, perhaps more popular foods, will be served to close friends. These are the foods that people serve when they want to relax and have a good time. Such foods may be similar to the favorite foods of the respondents.

One question ("What foods do you serve to friends you really like and are not trying to impress?") was asked to determine what foods fit in this classification. The percentages of respondents who answered within given food categories are presented in Table 9.

Table 9.—Percent of respondents who listed certain food items as foods they served to good friends

Food item	% of total sample	Food item	% of total sample
Chicken	31.0	Salads	10.0
Miscellaneous vegetables	22.7	Sweets	6.7
Potatoes	18.6	Spaghetti	5.5
Rice	16.3	Gumbo ,stew, and soup	5.3
Beef roast	16.1	Hamburgers	4.4
Fish, seafood, and crayfish	15.8	Ground beef	3.6
Barbecue	13.9	Tacos, pizzas, tamales	1.4
Same as family	13.6	Sandwiches	1.1
Steak	13.3	Miscellaneous	1.9
Pork	12.7		

All groups reported miscellaneous vegetables and potatoes at approximately equal rates as foods served to friends. Food items which were mentioned at significantly greater rates by certain groups are shown in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food items**
North Louisiana	Same foods as the family
South Louisiana	Beef roast Rice
Differences by race	
Whites	Seafood, fish and crayfish
Blacks	Chicken
Differences by locality by race	
North Louisiana Whites	Steak Same foods as the family
South Louisiana Whites	Beef roast
North Louisiana Blacks	None
South Louisiana Blacks	Rice
Differences by occupational prestige	
High	Steak Barbecue
Medium	None
Low	None

The categories of foods served to good friends were similar to those of the high status foods. However, the relative positions of the food categories for the total sample of respondents changed somewhat. Steak dropped from first on the high status list to ninth on the sociability list and chicken, which ranked fifth on the high status list, was the item most often mentioned as served to friends. Barbecue was another item that moved up on the sociability list from a relatively low position on the status list.

Despite relative changes in position for the total sample, the differences by subcultural groups for foods served to friends were very similar to those of the high status foods. For example, steak was a popular item with North Louisiana respondents and beef roast and rice were mentioned at greater rates by South Louisiana homemakers.

The upper occupational prestige group had a significantly greater ratio of responses to barbecue, steak, and salads than did the two lower groups. This reveals a meal pattern which is probably complete with the addition of potatoes for this group. Logically, the "steak cook-out" seems to be enjoyed most by those who can afford it. Respondents in the middle occupational prestige group were relatively high in their response to barbecue but not to steak, which indicates that a less expensive meat, such as chicken or hamburger, is a more popular barbecue item with them.

Favorite Foods—Favorite foods can be thought of as those that are most highly regarded or the most commonly consumed items, depending on individual tastes and perspectives. It is believed that foods listed as favorites that overlap in other categories will give clues to overall values of the homemakers. For example, if favorite foods are also high status foods, it can be hypothesized that social status is important to members of the subculture. The question "What foods are your family's favorites?" was asked of the respondents. The percentages of respondents who listed items in the given food categories for this question are shown in Table 10.

Table 10.—Percent of respondents who listed certain food items as their family's favorite food

Food item	% of total sample	Food item	% of total sample
Chicken	31.9	Greens	7.8
Miscellaneous vegetables	24.1	Gravy	7.5
Steak	23.6	Beef roast	6.9
Potatoes	21.9	Salads	5.8
Sweets	16.3	Fruit	5.3
Rice	15.0	Milk and cheese	5.0
Seafood and fish	13.6	Cornbread	5.0
Dry beans and peas	13.6	Crayfish	3.9
Ground beef	11.6	Bread	3.6
Pork	11.4	Soups, stews, gumbos	3.1
Spaghetti	8.0	Lunchmeat and weiners	1.7
		Miscellaneous	4.7

Chicken and rice were equally popular with all groups. Food items which were mentioned most often by any group at significantly greater rates are shown in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food item**
North Louisiana	Steak Miscellaneous vegetables Dry beans and peas Sweets
South Louisiana	None

Differences by race

Whites	Steak Potatoes
Blacks	Pork Greens

Differences by locality by race

North Louisiana Whites	Steak Beef roast Potatoes Sweets
South Louisiana Whites	None
North Louisiana Blacks	Dry beans and peas Greens
South Louisiana Blacks	None

Differences by occupational prestige

High	Steak Seafood and fish
Medium	None
Low	None

One interesting observation from the preceding outline is that no food appeared as a distinctive favorite of either group of South Louisiana respondents. Their favorite foods were chicken, potatoes, miscellaneous vegetables, and rice, which were also included in the favorite foods list of North Louisiana respondents. Also, it is interesting to note that beef roast was mentioned as a status food and as food to serve friends by the South Louisiana Whites significantly more often than by the remaining three subcultural groups, but only four of the South Louisiana Whites listed beef roast as a favorite food. It is possible that status and sociability aspects are in one category for the South Louisiana Whites and favorite foods are in a different category. However, the North Louisiana Whites seemed to place similar foods in the status, sociability, and favorite food categories. This finding suggests that the South Louisiana Whites accept a wider variety of foods on an "everyday" basis than do the North Louisiana Whites.

Steak and fish and seafood were mentioned as favorite foods with significantly greater frequency by the high occupational prestige group than by the other two groups. This finding supports the view that one's perspective of food changes in terms of what one can afford.

Wild Food—The consumption of wild foods is somewhat limited by the availability of the supply and the cost of obtaining the food, as well as by attitudes related to desirability. Certain items, such as fresh water fish, are more common than others, such as deer. Because of this, certain wild foods may be considered to have higher status than others. For example, wild duck is often considered a high status food, but raccoon is considered unacceptable as a food by many persons.

Respondents were asked one question concerning wild food consumption: "What wild game, fish, or wild plants do you eat? (Examples: squirrel, kind of fish, poke salad.)" The percentages of respondents who answered in given food categories are shown in Table 11.

Table 11.—Percent of respondents who listed certain wild food items as ones eaten by their family

Food item	% of total sample	Food item	% of total sample
Fish	82.0	Seafood and crayfish	21.9
Small mammals	37.7	Fowl	16.1
Deer	24.7	Plants and berries	15.0

All of the wild food categories had a response rate of at least 15 percent of the total sample. The categories more typical of certain groups than of the others are given in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food item**
North Louisiana	Deer Plants and berries
South Louisiana	Seafood and crayfish
Differences by race	
Whites	Seafood and crayfish Deer Fowl
Blacks	None
Differences by locality by race	
North Louisiana Whites	Deer Fowl
South Louisiana Whites	Seafood and crayfish
North Louisiana Blacks	Plants and berries
South Louisiana Blacks	None

Differences by occupational prestige

High	Seafood and crayfish Deer Fowl
Medium	None
Low	None

Fish and small mammals, which were readily accessible to most persons in this sample, were reported to be consumed by the total sample at the rates of 82 and 37.7 percent, respectively. Differences by groups in the analyses were not significant.

As was expected, the three wild food categories—deer, fowl, and seafood—which are more costly to obtain were listed most often by the Whites and the high occupational prestige group. North Louisiana Blacks reported a greater consumption of wild plants and berries than did the remaining three groups. Poke salad greens, dewberries and blackberries were the items mentioned most often in this category.

Beverages—Beverage consumption patterns vary by subcultures as do those for solid foods. Possibly more taboos are associated with beverages than with solid foods. For example, milk is sometimes considered unsafe when consumed with other food, such as fish; certain religious groups avoid alcoholic beverages, and other religious groups avoid coffee and tea as well as alcoholic beverages.

The question "What beverages do you purchase for your family and guests?" was included to round out the other food consumption patterns. The percentages of respondents who answered in given beverage categories are shown in Table 12.

Table 12.—Percent of respondents listing certain beverages as ones they purchased for their family

Beverage	% of total sample	Beverage	% of total sample
Milk	78.4	Citrus juice	27.7
Carbonated	78.1	Other juice	24.7
Tea	55.7	"Kool-Aid"	23.3
Coffee	47.7	Liquor	9.4
Beer	30.2	Wine	5.8

Beverages which varied by subcultural groups and were more typical of certain groups that others are included in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Beverage**
North Louisiana	Tea Citrus juices
South Louisiana	Beer
Differences by race	
Whites	Coffee Tea
Blacks	"Kool-Aid"
Differences by locality by race	
North Louisiana Whites	Coffee Tea
South Louisiana Whites	Liquor
North Louisiana Blacks	"Kool-Aid"
South Louisiana Blacks	Citrus juices Other juices
Differences by occupational prestige	
High	Coffee Juices other than citrus Beer Liquor
Medium	None
Low	None

All groups reported milk and carbonated beverages at approximately equal rates. The South Louisiana Blacks reported the highest consumption rates for citrus juices, whereas consumption rates by the South Louisiana Whites were the lowest of all four subgroups. It is interesting to note that similar differences were found in the citrus fruit category for the question on healthful foods. For some reason the South Louisiana Blacks seemed to place a higher value on citrus fruits and juices than did the other three subcultural groups.

Different subcultural patterns in reported beer and liquor purchases seem to be related to different factors. The South Louisiana Whites reported the highest purchase rates for both items, but the South Louisiana Blacks were the second highest group in the beer category and the North Louisiana Whites were the second highest in the liquor category. This suggests that differences by locality are greater for beer purchases and differences by race are greater for "hard" liquor purchases. Economic level might be responsible for choice of alcoholic beverages, except that respondents in the high occupational prestige group listed both beer and liquor at greater rates than did the two lower groups.

The differences by subcultural groups in reported coffee purchases were unexpected, as South Louisiana is known for its distinctive coffee. The North Louisiana Whites had the highest ratio of respondents in this category and the South Louisiana Blacks had the lowest ratio. These differences may be associated with breakfast patterns, as more of the North Louisiana respondents ate breakfast on the day of the interview than did the South Louisiana respondents.

Superstitions Regarding Food—One question was concerned with taboos or superstitions related to food. The question was, "Do you know of any combinations of foods that you should not serve together? If yes, what are they?" The percentages of respondents who answered in each food category are given in Table 13. Since there were only two categories and only one significant difference, an outline of differences is not presented for this question.

Table 13.—Percent of respondents who listed certain combinations of food items that should not be eaten together

Food item	% of total sample
Fish and milk	22.7
Other	9.1

Almost 23 percent of the respondents volunteered the response of fish and milk. However, there were no statistically significant differences between any of the groups in ratios of response. All of the other taboos were placed in one catgory. Examples of those mentioned were: alcohol and watermelon, bananas and whiskey, fish and bananas, greens and fish, pickles and milk, and beans and fish. The statistically significant differences in responses in the "other" category were due mainly to race, but the South Louisiana Blacks had a much greater response rate in this category than did the other groups and the South Louisiana Whites had the lowest rates of response.

All taboos were totaled for each group and analyzed as one category. No significant differences between groups were found. These results are from a very limited sample, but they do bring into question the theory that superstitions decrease with increased knowledge and experience since no differences were found by occupational prestige.

Health: Foods Thought to Be High in Nutritive Value—Practically all items consumed by human beings contain some nutritive value, but there is great variation in the quantity and quality of nutrients provided by different foods. For example, lettuce has little nutritive value compared with that of spinach. Due to this great variation much confusion exists regarding the nutritive value of specific foods.

The following question was designed to determine which foods the respondents associated with good health: "What would you serve if you wanted to serve food that is very good (healthy) for you?" The percentages of respondents who answered in given food categories are shown in Table 14.

Dairy products, potatoes and miscellaneous vegetables were reported at similar rates by all groups.

Table 14.—Percent of respondents listing certain foods as good (healthy) for them

Food item	% of total sample	Food item	% of total sample
Miscellaneous fruits and vegetables	59.8	Dry beans and peas	10.8
Beef	45.2	Sweets	7.2
Dairy products	29.1	Liver	5.8
Greens	25.2	Eggs	5.8
Potatoes	21.9	Pork	5.0
Salads	19.7	Citrus fruit	4.4
Rice	14.1	Fish	4.2
Breads and cereals	12.7	Soups, stews, gumbos, etc.	1.7
Chicken	11.1	Miscellaneous	5.3

Categories of food which were mentioned by 15 percent of any group at a significantly greater rate than by other groups as "healthy" foods are listed in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food item**
North Louisiana	Breads and cereals Green vegetables Dry beans and peas
South Louisiana	Rice
Differences by race	
Whites	Salads Beef
Blacks	Greens

Differences by locality by race

North Louisiana Whites	Beef
South Louisiana Whites	None
North Louisiana Blacks	Greens
South Louisiana Blacks	Chicken Citrus fruits

Differences by occupational prestige

High	Beef Salads
Medium	None
Low	None

Responses to the question on "healthy" foods were categorized under the Basic Four Food Groups, a simple scheme devised by nutritionists to simplify diet planning and evaluation. The responses were then evaluated on the basis of the relative nutritive values of foods mentioned within each of the four food groups.

The first basic food group, milk and milk products, mainly contributes protein, calcium and riboflavin to diets. Only 29 percent of the respondents mentioned a dairy product as a "healthy" food.

Meat and other protein foods, the second basic food group, make outstanding contributions of protein, B vitamins and iron to the diet. Eggs, legumes and nuts are also included in this group. Eggs, which are very high in nutritive value, were mentioned as a "healthy" food by only 5.8 percent of the homemakers. Legumes or dry beans and peas were listed by 10.8 percent of the respondents. One common misconception seems to be that there are great differences in nutritive value between various types of meat; however, differences in the amounts of the major nutrients furnished by the flesh of mammals, birds, fish and shell fish are minor. Meats listed as "healthy" food, and the percentage of respondents mentioning each, were beef, 45.2; chicken, 11.1; pork, 5.0, and fish, 4.2.

The vegetable and fruit group is the only source of ascorbic acid and the main source of vitamin A in the U.S. diet. Potatoes, which contribute some iron, ascorbic acid and thiamine to diets, were mentioned by 21.9 percent of the respondents. Dark-green vegetables, which are excellent sources of calcium, iron, provitamin A, ascorbic acid and riboflavin, were listed by 25.2 percent of the interviewees. Including one serving of citrus fruit or juice in the diet generally insures that the recommended daily allowance of ascorbic acid has been met. However, citrus fruits were mentioned as a "healthy" food by only 4.4 percent of the housewives interviewed and half of these were South Louisiana

Blacks. Only one South Louisiana White listed a citrus fruit as a "healthy" food. Other fruits and vegetables contribute significantly smaller amounts of nutrients to the diet. Approximately 60 percent of the persons questioned mentioned an item in this category. These findings reveal that vegetables and fruits were thought to be nutritious food items, although the choices were vegetables which were not considered excellent sources of the two major vitamins.

Enriched, whole grain, or restored grains and cereals, the fourth basic food group, are important sources of B vitamins, iron and some protein. Rice was mentioned by twice as many South Louisiana respondents as North Louisiana respondents as a "healthy"' food. However, the most popular type of rice eaten in the South Louisiana area is an unenriched product which has lost minerals and vitamins during milling. Breads and cereals, which are either whole grain or enriched, were listed by twice as many North Louisiana homemakers as South Louisiana homemakers.

The responses described in the preceding discussion reveal certain misconceptions concerning the nutritive value of foods. Little attention was given to the individual subgroups in this study, but it is evident that the North Louisiana respondents had a greater awareness of some of the more nutritious foods, such as enriched breads and cereals and green vegetables, than did the South Louisiana respondents.

Summary—Analysis of the responses to the questions concerning foods suggests that certain foods are, in fact, associated with certain attitude concepts. A composite of the responses to all questions reveals certain patterns of food consumption for the subgroups as well as for the total sample.

Chicken, beef, potatoes, miscellaneous fruits and vegetables, and cornbread seemed to be important in the diets of all respondents. Other foods most often mentioned by the subcultural groups were: North Louisiana—steak, greens, dry beans and peas, and sweets; South Louisiana—seafood, fish, and crayfish, beef roast, and rice; Blacks—pork, greens, dry beans and peas, and rice; Whites—steak, potatoes, and seafood and fish.

Prevalent Patterns in Actual Food Consumption

As noted in the preceding summary, subcultural patterns appeared when responses to all questions were viewed as a "whole." To validate these as subcultural patterns, foods reported eaten in the 24 hours prior to the interview were tabulated within selected categories. The categories are not mutually exclusive since some foods were representative of more than one category, such as potato salad being listed as potatoes and salad. A food was listed only once for a respondent even if she reported having eaten it more than once.

The food items eaten by the respondents at least once in the 24 hours prior to the interview are listed in Table 15 in descending order

Table 15.—Number and percent of total respondents and percentages of four subcultural groups who reported having eaten a given food during the previous 24 hours

Food item	Total (N=362)		No. Louisiana Whites (N=108)	No. Louisiana Blacks (N=71)	So. Louisiana Whites (N=130)	So. Louisiana Blacks (N=53)
	No.	%				
Meats			Percent			
Chicken	82	22.65	17	31	22	25
Beef steak (all kinds)	70	19.34	13	13	26	4
Fish and seafood	56	15.47	15	7	20	17
Bacon	52	14.36	14	42	4	4
Hamburgers and weiners	41	11.33	16	11	7	13
Pork roast and hams	40	11.05	15	13	5	17
Misc. ground beef dishes	34	9.39	13	13	6	4
Pork chops	31	8.56	7	13	7	9
Pork sausage	29	8.01	9	17	2	8
Beef roast	28	7.73	13	6	6	4
Lunchmeat and weiners	27	7.46	11	7	5	8
Wild meat	13	3.59	1	6	7	0
Liver	7	1.93	1	3	2	2
Breads and Cereals						
Commercial loaf breads	200	55.25	60	85	41	42
Rice	139	38.40	14	27	54	66
Cornbread and cush-cush	76	20.99	34	45	2	8
Breakfast cereals	61	16.85	12	31	18	6
Biscuits	34	9.39	10	7	13	2
Yeast rolls	34	9.39	21	11	2	0
Milk and Cheese	230	63.54	60	72	69	45

(Continued)

Table 15.–(Continued)

Food item	Total (N=362) No.	Total (N=362) %	No. Louisiana Whites (N=108)	No. Louisiana Blacks (N=71)	So. Louisiana Whites (N=130)	So. Louisiana Blacks (N=53)
Vegetables and Fruits			Percent			
Miscellaneous vegetables	162	44.75	60	28	48	28
Dry beans and peas	155	42.82	50	46	38	36
Potatoes	116	32.04	46	20	30	25
Miscellaneous fruits	70	19.34	26	24	16	8
Greens	55	15.19	22	28	6	6
Citrus fruits	39	10.77	10	7	12	13
Beverages						
Milk	208	57.46	49	68	60	42
Coffee	207	57.18	64	52	60	45
Soft Drinks	124	34.25	43	48	32	6
Tea	97	26.80	48	20	20	13
Citrus juice	82	22.65	21	28	27	11
Miscellaneous beverages	28	7.73	10	10	56	8
Miscellaneous fruit juice	18	4.97	10	8	6	2
Alcoholic beverages	15	4.14	6	1	6	0
Miscellaneous						
Sweets	212	58.56	95	58	40	30
Salads	127	35.08	39	21	46	19
Eggs	105	29.01	33	44	23	15
Sandwiches	77	21.27	25	21	23	9
Gravy	42	11.60	7	21	10	11
Casseroles and spaghetti	28	7.73	11	7	7	4
Stew, soup and gumbo	26	7.18	7	7	8	6

within major categories with the number and percentage of total respondents and the percentage within each subcultural group who reported having eaten the item.

Items that varied significantly by locality or race are shown in the following outline with the subgroup that had the highest response rate for each item.

Differences by locality	**Food item**
North Louisiana	Ground beef
	Bacon
	Pork sausage
	Commercial loaf breads
	Cornbread
	Yeast rolls
	Greens
	Miscellaneous fruits
	Eggs
	Sweets
	Tea
	Soft drinks
South Louisiana	Fish and seafood
	Rice
Differences by race	
Whites	Biscuits
	Miscellaneous vegetables
	Potatoes
	Sweets
	Wild meat and fish
	Salad
	Tea
	Alcoholic beverages
Blacks	Bacon
	Pork sausage
	Cornbread
	Commercial loaf breads
	Gravy

Analyses of foods consumed by the four race-by-locality groups emphasize subcultural intake differences even more than do the analyses by race or locality. Twenty items that varied significantly by subgroups are listed in the following outline with the subgroup that had the highest response rate for each item and the subgroup that had the lowest response rate.

Locality by race	Highest of four subcultural groups	Lowest of four subcultural groups
North Louisiana Whites	Misc. vegetables Potatoes Misc. fruits Sweets Tea Coffee Soft drinks	Rice Gravy
North Louisiana Blacks	Bacon Pork sausage Commercial loaf breads Cornbread Breakfast cereals Greens Eggs Gravy Milk	Potatoes Misc. vegetables
South Louisiana Whites	Wild meats, fish and seafoods Salads	Pork roast and ham Bacon Pork sausage Commercial loaf breads Cornbread Greens
South Louisiana Blacks	Pork roast and ham Rice	Bacon Breakfast cereals Misc. vegetables Greens Misc. fruits Eggs Sweets Wild meat and fish Salads Milk Tea Coffee Soft drinks

Foods consumed by all four groups that did not differ significantly by subcultural groups were chicken, steak (all kinds), hamburgers, pork chops, beef roast, milk and cheese, dry beans and peas, citrus fruits, citrus juice, sandwiches, casseroles, spaghetti, and stews, soups and gumbos.

The North Louisiana Whites reported more foods that are surplus to dietary needs, such as sweets, tea, coffee and soft drinks. These items, plus greater consumption rates of miscellaneous vegetables and fruits, suggest that their diets have more variety than those of the other three subcultural groups.

The North Louisiana Black respondents reported having eaten more "soul" food than the other three groups, i.e., pork, cornbread, greens, and gravy. They also reported greater amounts of typical "breakfast" foods, notably bacon, sausage, cereals and eggs. Most of these items are relatively high in minerals and vitamins.

One of the most notable features of the diet of South Louisiana Whites was the relative scarcity of pork and bread. The high consumption rate of fish, seafood and wild meats was expected, due to known ease of acquisition. However, it should be noted that the South Louisiana Blacks reported the least amount of wild meat and fish consumed of the four subcultural groups; therefore, locality is not the only explanation for the high consumption rate in this category by the South Louisiana Whites. Traditions from the French subculture are evident in the diets of the South Louisiana Whites.

Dietary items reported by the South Louisiana Blacks suggest they had less variety than did the other three groups. Two-thirds of the South Louisiana Black homemakers reported having eaten rice and 36 percent reported they had eaten dry beans and peas. Even though the study was done during the garden vegetable season, only 28 percent reported having eaten vegetables in the miscellaneous category. These findings suggest that rice and dry beans are year-round staples in the diets of the South Louisiana Blacks. Similar to responses of the North Louisiana Blacks, chicken was the meat most often reported as having been eaten. Breakfast foods such as bacon, cereal and eggs were reported at lower rates by this group than by the other three groups. The South Louisiana Blacks also reported low rates of "luxury" items such as sweets, salads, tea, coffee, and soft drinks.

Summary–In general, the diets of the North Louisiana White homemakers included a larger variety of items than did the diets of the other three groups. Most of the differences reflected "surplus" dietary items rather than those items that provide significant amounts of essential nutrients. The inclusion of more fruits and vegetables in their diets than in the diets of the other groups probably does make a significant contribution to their overall nutrient intake, however. The opposite extreme group, the South Louisiana Blacks, had much less variety in their diets than did the other three subcultural groups. Rice and dry beans were obviously a basic part of their diets. It could be expected that nutritionists and others who are interested in improving the diets of populations would have a much more difficult time introducing new foods into the diets of the latter group than into the diets of the other groups.

Meal Patterns

Food habits also vary by when foods are eaten, as well as by what is actually eaten. It is generally easier to balance diets and maintain weight control if food intake is distributed throughout the day rather than being concentrated into one or two heavy meals. Clues to differences in meal patterns by subcultural groups were given in the preceding section on food actually eaten.

The percentages of respondents in each subcultural group who ate the various meals are shown in Table 16.

Table 16.—Percent of respondents in four subcultural groups who ate breakfast, lunch, dinner and snacks

Meal	No. Louisiana Whites (N=108)	No. Louisiana Blacks (N=71)	So. Louisiana Whites (N=130)	So. Louisiana Blacks (N=53)
	Percent			
Breakfast	55.6	84.5	52.0	35.9
Lunch	88.9	90.1	91.5	88.7
Dinner	90.7	83.1	90.0	81.1
Snacks	83.3	63.4	59.2	60.3

Differences in numbers of respondents who ate breakfast were statistically significant. Aproximately 85 percent of the North Louisiana Blacks reported having eaten breakfast as compared with only 36 percent of the South Louisiana Blacks. This one meal probably accounts for the great difference in food consumption between the two groups. Ninety percent of all respondents had eaten a noon meal and 88 percent had eaten a night meal.

The North Louisiana homemakers ate significantly more snacks than did the South Louisiana homemakers. In fact, 83 percent of the Whites and 63 percent of the Blacks in the North Louisiana community ate snacks as compared with approximately 60 percent of both Blacks and Whites in South Louisiana.

Meal patterns were also examined from another standpoint. Percentages of the daily caloric intake furnished by each meal were calculated. Least squares analysis of covariance with controls for education, income and age revealed further subcultural patterns. The distributions of calories in the various meals for each of the four subcultures are shown in Table 17.

As would be expected, the percentage of calories consumed at breakfast revealed a pattern similar to the number of persons who ate breakfast. The North Louisiana Blacks consumed a larger portion of

Table 17.—Adjusted means of percentages of total day's calories eaten at breakfast, lunch, dinner and snacks by four subcultural groups

Meal	North Louisiana Whites	North Louisiana Blacks	South Louisiana Whites	South Louisiana Blacks
	— — — — — — — — — % calories	— — — — — — — — —		
Breakfast	13.56	21.62	18.83	8.83
Lunch	31.34	36.06	37.96	44.00
Dinner	39.13	31.14	39.39	34.36
Snacks	15.96	11.21	8.88	12.79

their daily food intake at breakfast than did any of the other three groups. The low 8.83 percent of calories consumed at breakfast by the South Louisiana Blacks contributes to a significant locality-by-race interaction effect. Interestingly, the North Louisiana Whites and the South Louisiana Blacks consumed more calories in snacks than in breakfasts. These snack calories probably represent less nutritious foods than those eaten at regular meals.

The South Louisiana homemakers reported a mean of 39.7 percent of all calories at the noon meal as compared with 33.2 percent for the North Louisiana homemakers, a statistically significant difference. It should be noted that almost one-half of the total caloric intake was consumed at noon by the South Louisiana Blacks. This type of meal pattern is very difficult to balance nutritionally.

The Whites consumed significantly more at night than did the Blacks, as was shown by mean percentages of total calories of 39.4 and 32.5, respectively. This distribution was compensated for by the North Louisiana Blacks at breakfast and by the South Louisiana Blacks at noon. Although no standard recommendations exist for distribution of caloric intake, nutritionists generally believe that breakfast is an important meal and food intake should be distributed throughout the day. Using this view as a standard, the North Louisiana Blacks had the most desirable meal pattern and the South Louisiana Blacks had the last desirable meal pattern.

Summary and Conclusions

As noted by Dressler (1972, p. 59) and others, food choices are one distinguishing feature of subcultures. Not only do subcultures vary by when and what they eat, but they are also believed to vary by the meanings they attach to specific foods. The major purpose of the research reported in this bulletin was to determine the specific foods that members of selected subcultures in Louisiana associate with certain behavioral concepts. The subcultures studied were North Louisiana

Whites and Blacks and South Louisiana Whites and Blacks. In addition, subcultural differences in foods actually consumed in the 24 hours prior to the interview and in meal patterns were also studied.

North Louisiana Whites

The distinguishing aspect of the subcultural meal pattern of the North Louisiana Whites was that 15 percent of their calories were consumed in snacks and 83 percent of all North Louisiana Whites had at least one snack in the 24 hours prior to the interview. Snack foods included items high in calories and low in minerals and vitamins. This group of homemakers reported consuming more "sweets," soft drinks, tea and coffee than did the other three groups. On the other hand, they had higher consumption rates of miscellaneous vegetables, potatoes and miscellaneous fruits than did the other three subcultural groups. These foods are sources of minerals and vitamins, which might be some compensation for the high consumption of "empty calories." They also ate significantly less rice and gravy than did the other three groups.

Food items that often appeared to be related to selected behavioral concepts were beef (steak, ground beef, and roast) chicken, sandwiches, sweets, dry beans and peas, potatoes, and spaghetti. The North Louisiana Whites seemed to value foods prepared by their mothers more than did the South Louisiana Whites. Foods identified by this group as convenience foods are much easier and faster to prepare than were those listed by the South Louisiana Whites. Responses to questions concerned with status foods, family favorites, and foods served to good friends were somewhat consistent in that steaks, chicken, "sweets" and potatoes appeared often on all three lists. It seems safe to assume that these items were highly valued in the diets of the North Louisiana White homemakers. Generally, tradition, status and convenience were important concepts to the North Louisiana White homemakers, as noted by the foods delineated in these categories.

North Louisiana Blacks

The North Louisiana Blacks consumed a greater percentage of calories at breakfast than did the other three groups. In fact, 84.5 percent of them reported having eaten breakfast on the day of the interview. They were the only group that had a greater percentage who ate breakfast than ate dinner or snacks. This meal pattern was responsible for significant differences in actual foods eaten in the 24 hours prior to the interview. The North Louisiana Black homemakers consumed more bacon, pork sausage, breakfast cereals, eggs, and milk than did homemakers in the other three groups. This group also ate more cornbread, greens, and gravy ("soul" foods) than did the others. They had the lowest consumption of potatoes and miscellaneous vegetables.

Most of the foods that were distinctive of this group are good sources of necessary nutrients. Foods that were listed as ones their mothers prepared (traditional) were the foods that appeared most often as distinctive of the North Louisiana Blacks in responses to the questions related to other selected concepts. These were pork, greens, and dry beans and peas. Wild plants and berries were also eaten in significantly greater amounts by the North Louisiana Blacks than by the other three groups of homemakers. Tradition seems to be the most influential of the concepts studied in determining the food choices of North Louisiana Black homemakers.

South Louisiana Whites

The most unique feature of the meal pattern of South Louisiana Whites was a relative low percentage of calories in snack foods. They consumed only three categories of food at greater rates than did the other three groups. These were salads, wild meat, and fish and seafood. The South Louisiana Whites had the lowest consumption rates of pork roast, ham, bacon, pork sausage, greens, and cornbread—typical Southern "soul" foods.

Interestingly, fish, seafood and crayfish were items reported to have been prepared by their husbands' mothers. Their own mothers probably prepared these foods also but the influence of the husbands on food choices may be more recognizable in the South Louisiana Whites. The South Louisiana Whites seldom listed a sandwich as a food they prepared when in a hurry. The hamburger was listed more often by these women, implying that they placed less value on convenience than did the North Louisiana homemakers.

Beef roast was listed more often by the South Louisiana Whites as a status food and as one served to friends; however, only four homemakers in this group listed it as a favorite food. This is a somewhat different pattern than that of the North Louisiana Whites, who tended to list the same foods in all three categories. Chicken and rice were often mentioned as favorite foods, but no more frequently than by the other homemakers.

The findings suggest that food for others and food for family are somewhat distinct categories for the South Louisiana Whites, whereas the North Louisiana Whites want the same things for themselves that they want to serve others. Ease of accessability, the South Louisiana heritage, and French culture are believed to contribute to the greater emphasis on seafood by this group.

The choices of the South Louisiana White homemaker seem to be more related to her husband and her family's needs than to other concepts, such as status and convenience.

South Louisiana Blacks

The noon meal of the South Louisiana Blacks was the dominant meal of the day. Forty-four percent of the calories consumed by this group in the 24 hours prior to the interview were eaten at noon. Less than 9 percent of their total calories were consumed at breakfast. Members of this group obviously had less variety in their diets than did any of the other study groups. They were the highest consumers of pork roast, ham, and rice, but the lowest in consumption of 13 of the 25 items that varied significantly by subculture. Dry beans, rice, gravy and a little meat (pork and chicken) appeared to be a characteristic meal. The South Louisiana Black homemakers seemed to value satiety above the concepts investigated. Sociability aspects, family, status, convenience, and health were less influential in their choices of food.

General Conclusions

Findings from the research reported here support the belief that specific foods do have connotative meanings, and foods associated with these meanings do vary by subculture. The findings also suggest that certain meanings are more important to certain groups than to other groups. It can be hypothesized that tradition is important to all four groups. Status and convenience seemed to be more important to North Louisiana White homemakers, and family obligations seemed to dominate the choices of the South Louisiana White homemakers. Both groups of Blacks seemed bound to traditional foods.

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APPENDIX

TABLES OF STATISTICALLY SIGNIFICANT X^2 VALUES FOR FOODS ASSOCIATED WITH SELECTED CONCEPTS

Table A-1.--Differences by locality in food items respondents prepared which their mothers prepared

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Chicken	48/35	24/37	72	9.0**
Greens	38/21	5/22	43	26.6***
Beans	41/28	17/30	58	11.0***
Rice	9/19	30/20	39	10.5**
Sweets	17/25	33/26	50	4.5*

Table A-2.--Differences by race in food items respondents prepared which their mothers prepared

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Chicken	57/48	15/25	72	5.6*
Beef	30/23	5/12	35	6.1*
Pork	15/21	16/11	31	4.4*
Greens	19/28	24/15	43	9.2**
Rice	33/26	6/13	39	6.1*
Potatoes	39/32	9/16	48	5.0*

Table A-3.--Differences by race and locality in food items respondents prepared which their mothers prepared

	N. La.		S. La.			
Food items	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Chicken	34/22	14/14	23/26	1/11	72	16.3***
Beef	21/11	3/ 7	9/13	2/ 5	35	15.5***
Pork	14/ 9	11/ 6	1/11	5/ 5	31	16.0**
Greens	18/13	20/ 8	1/16	4/ 6	43	33.4***
Beans	24/17	17/11	12/21	5/ 9	58	11.1*
Rice	7/12	2/ 7	26/14	4/ 6	39	16.8***

NOTE.--For all Appendix tables, the following applies:

[1] Observed N/Expected N.

*p <.05, **p <.01, ***p <.001 on two-tailed X^2 test.

Table A-4.--Differences by occupational prestige in food items respondents prepared which their mothers prepared

Food items	Occupational prestige level			Total	X^2
	Low ON/EN[1]	Medium ON/EN[1]	High ON/EN[1]	N	value
Chicken	16/20	29/34	27/17	72	7.8*
Everything	13/19	27/30	24/15	64	6.7*
Beef	5/10	17/17	13/ 8	18	5.0*

Table A-5.--Differences by race and locality for food items respondents prepared which their husbands' mothers prepared

Food items	N. La.		S. La.		Total	X^2
	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]	N	Value
Seafood & crayfish	3/8	2/5	16/9	4/4	25	9.8*

Table A-6.--Differences by locality in food items respondents prepared when in a hurry

Food item	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Sandwich	82/56	32/58	114	23.9***

Table A-7.--Differences by race in food items respondents prepared when in a hurry

Food items	White ON/EN[1]	Black ON/EN[1]	N	X^2 value
Hamburgers	67/56	18/29	85	6.2*

Table A-8.--Differences by locality and race in food items respondents prepared when in a hurry

Food items	N. La. White ON/EN[1]	N. La. Black ON/EN[1]	S. La. White ON/EN[1]	S. La. Black ON/EN[1]	Total N	X^2 value
Sandwich	53/34	29/22	23/41	9/17	114	22.5***
Hamburgers	25/26	9/16	42/31	9/13	85	8.5*
Frozen	18/ 9	4/ 6	7/10	0/ 4	29	18.8***

Table A-9.--Differences by locality in food items respondents considered expensive

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Beef	53/67	83/69	136	5.5*
Seafood	30/22	14/22	44	6.5*
Vegetables or fruit	49/39	30/40	79	5.4*
Steak	84/61	40/63	124	17.4***

Table A-10.--Differences by race in food items respondents considered expensive

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Pork	33/45	35/23	68	9.3**

Table A-11.--Differences by locality and race in food items respondents considered expensive

Food items	N. La. White ON/EN[1]	N. La. Black ON/EN[1]	S. La. White ON/EN[1]	S. La. Black ON/EN[1]	Total N	X^2 value
Pork	15/20	26/13	18/25	9/10	68	16.6***
Seafood	23/13	7/ 8	9/16	5/ 7	44	10.8*
Vegetables or fruit	38/24	11/15	22/28	8/12	79	12.4**
Steak	50/37	34/24	27/45	13/19	124	17.6***

Table A-12.--Differences by occupational prestige in food items respondents considered expensive

Food items	Occupational prestige level			Total N	X^2 value
	Low ON/EN[1]	Medium ON/EN[1]	High On/EN[1]		
Pork	29/20	25/32	14/16	68	6.2*

Table A-13.--Differences by locality in food items respondents considered inexpensive

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Spaghetti	34/27	20/28	54	4.2*
Local vegetables and fruits	77/63	51/65	128	6.4*
Rice	26/37	49/38	75	6.2*
Cornbread	34/25	16/26	50	7.2*

Table A-14.--Differences by race in food items respondents considered inexpensive

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Ground meat	79/65	19/33	98	9.3**
Eggs	40/28	3/15	43	14.0***
Stews, soups and gumbo	42/25	8/26	50	24.5***

Table A-15.--Differences by locality and race in food items respondents considered inexpensive

Food items	N. La.		S. La.		Total N	X^2 value
	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]		
Ground meat	48/29	6/19	31/35	13/15	98	21.0***
Spaghetti & macaroni	28/16	6/10	12/19	8/ 8	54	13.2**
Local vegetables & fruits	42/38	35/24	40/46	11/19	128	9.4*
Rice	13/23	13/14	32/27	17/11	75	8.0*

Table A-16.--Differences by occupational prestige in food items respondents considered inexpensive

Food items	Occupational prestige level Low ON/EN[1]	 Medium ON/EN[1]	 High ON/EN[1]	Total N	X^2 value
Ground meat	15/28	52/46	31/24	98	10.0**
Chicken	55/42	55/68	34/35	145	6.5*

Table A-17.--Differences by locality in food items respondents considered healthy

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Bread & cereals	31/23	15/23	46	5.6*
Rice	17/25	34/26	51	5.1*
Greens	65/45	26/46	91	17.6***
Dry beans & peas	26/19	13/20	39	5.1*

Table A-18.--Differences by race in food items respondents considered healthy

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Beef	132/108	31/55	163	15.8***
Salad	57/47	14/24	71	6.3*
Greens	42/60	49/31	91	15.9**

Table A-19.--Differences by locality and race in food items respondents considered healthy

Food items	N. La. White ON/EN[1]	 Black ON/EN[1]	S. La. White ON/EN[1]	 Black ON/EN[1]	Total N	X^2 value
Beef	68/49	21/31	64/59	10/25	163	19.7***
Chicken	15/12	6/ 8	6/14	13/ 6	40	14.1*
Citrus fruit	3/ 5	4/ 3	1/ 6	8/ 2	16	18.1***
Greens	32/27	33/17	10/38	16/14	91	30.8***

Table A-20.--Differences by occupational prestige in food items respondents considered healthy

Food items	Occupational prestige level Low ON/EN[1]	 Medium ON/EN[1]	 High ON/EN[1]	Total N	X^2 value
Beef	29/47	82/76	52/39	163	12.7**
Salad	11/18	32/29	28/15	61	35.1***

Table A-21.--Differences by locality in food items respondents considered as high status foods

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Steak	67/45	25/47	92	20.9***
Roast	28/40	53/41	81	6.8**
Rice	10/30	51/31	61	26.0**
Sweets	42/23	4/24	46	33.1***
Crayfish	2/20	38/20	40	31.0***

Table A-22.--Differences by race in food items respondents considered as high status foods

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Beef roast	62/54	19/28	81	4.0*
Rice	32/40	29/21	61	5.0*

Table A-23.--Differences by town and race in food items respondents considered as high status foods

Food items	N. La. White ON/EN[1]	 Black ON/EN[1]	S. La. White ON/EN[1]	 Black ON/EN[1]	Total N	X^2 value
Steak	50/28	17/18	17/33	8/14	92	28.5***
Roast	22/24	6/17	40/29	13/12	81	9.8*
Rice	6/18	4/12	26/22	25/ 9	61	41.4***
Sweets	26/14	16/ 9	4/17	0/ 7	46	33.4***
Crayfish	2/12	0/ 8	33/14	5/ 6	40	40.1**

Table A-24.--Differences by locality in total responses of food items respondents considered as low status foods

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Total responses	101/78	59/82	160	12.8**

Table A-25.--Differences by locality and race in food items respondents considered as low status foods

Food items	N. La. White ON/EN[1]	N. La. Black ON/EN[1]	S. La. White ON/EN[1]	S. La. Black ON/EN[1]	Total N	X^2 value
Ground beef & weiners	19/ 9	0/ 6	9/11	3/47	31	20.0***
Total responses	64/48	37/30	39/58	20/24	160	13.4**

Table A-26.--Differences by locality in food items respondents considered unacceptable

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Total responses	72/52	35/55	107	14.4***

Table A-27.--Differences by locality in food items respondents considered appropriate for their best friends

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Beef roast	15/28	43/30	58	12.4***
Rice	10/29	49/30	59	24.2***
Same as family	23/24	16/25	49	6.6*

Table A-28.--Differences by race in food items respondents considered appropriate for their best friends

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Chicken	61/74	51/38	112	6.6*
Fish, seafood & crayfish	45/38	12/19	57	4.3*

Table A-29.--Differences by locality and race in food items respondents considered appropriate for their best friends

	N. La.		S. La.			
Food items	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Beef roast	12/17	3/11	33/21	10/9	58	14.7**
Steak	22/14	7/ 9	16/17	3/7	48	8.3*
Rice	5/18	5/11	27/21	22/9	59	33.7***
Same as family	24/15	9/ 9	9/18	7/7	49	10.2*

Table A-30.--Differences by occupational groups in food items respondents considered appropriate for their best friends

	Occupational prestige level				
Food items	Low ON/EN[1]	Medium ON/EN[1]	High ON/EN[1]	Total N	X^2 value
Steak	7/ 14	18/23	23/12	48	15.9***
Barbeque	7/ 15	26/24	17/12	50	6.2*
Salad	7/10	10/17	10/ 9	36	16.6***

Table A-31.--Differences by locality for favorite foods

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X2 value
Steak	59/43	26/42	85	12.1***
Beef	13/20	37/20	40	35.7***
Miscellaneous vegetables	54/43	33/44	87	6.0*
Dry beans & peas	35/24	14/25	49	9.9**
Sweets	46/29	13/30	59	19.8***

Table A-32.--Differences by race for favorite foods

Food items	White ON/EN[1]	Black ON/EN[1]	N	X^2 value
Steak	76/59	9/29	85	20.9 ***
Pork	21/27	20/14	41	3.9 *
Potatoes	64/52	15/27	79	8.1 **
Greens	9/18	19/10	28	12.6 ***

Table A-33.--Differences by locality and race for favorite foods

	N. La.		S. La.			
Food items	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Steak	52/25	27/16	24/31	2/13	85	45.2 ***
Beef roast	17/ 7	3/ 5	4/ 9	1/ 4	25	45.8 ***
Potatoes	37/24	8/15	27/28	7/12	79	12.4 **
Beans	19/15	16/ 9	9/18	5/ 7	49	11.6 **
Greens	7/ 9	18/ 5	2/10	1/ 4	28	42.9 ***
Sweets	29/18	17/11	10/21	3/ 9	59	19.8 ***

Table A-34.--Differences by occupational prestige for favorite foods

Food items	Occupational prestige level Low ON/EN[1]	Medium ON/EN[1]	High ON/EN[1]	Total N	X^2 value
Steak	10/25	39/40	36/20	85	21.8***
Seafood	6/14	24/23	19/12	49	8.7*

Table A-35.--Differences by locality in wild food items respondents prepared for their families

Food items	N. La. ON/EN[1]	S .La. ON/EN[1]	Total N	X^2 value
Seafood & crayfish	11/39	68/40	79	38.9***
Deer	57/44	32/45	89	8.1**
Plants	43/27	11/28	54	20.2***

Table A-36.--Differences by race in wild food items respondents prepared for their families

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Seafood	65/52	14/27	79	9.4**
Deer	73/59	16/30	89	10.2**
Fowl	52/38	6/20	58	14.3***

Table A-37.--Differences by locality and race in wild food items respondents prepared for their families

	N. La.		S. La.			
Food items	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Seafood	11/24	0/15	54/28	14/12	79	45.3***
Deer	45/27	12/17	28/32	4/13	89	21.0***
Fowl	29/17	2/11	23/21	4/ 9	58	17.8***
Plants & berries	25/16	18/10	10/19	1/ 8	54	21.4**

Table A-38.--Differences by occupational prestige in wild food items respondents prepared for their families

	Occupational prestige level				
Food items	Low ON/EN[1]	Medium ON/EN[1]	High ON/EN[1]	Total N	X^2 value
Seafood & crayfish	12/23	44/37	23/19	79	7.3*
Deer	12/26	44/42	33/21	89	13.8**
Fowl	4/17	29/27	25/14	58	18.7***

Table A-39.--Differences by locality in beverage items respondents purchased for their families

Food items	N. La. ON/EN[1]	S. La. ON/EN[1]	Total N	X^2 value
Tea	115/99	86/103	201	5.4*
Citrus juices	59/49	41/51	100	4.0*
Beer	31/53	78/56	109	18.4**

Table A-40.--Differences by race in beverage items respondents purchased for their families

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X^2 value
Coffee	143/114	29/59	72	22.6***
Tea	149/133	52/68	201	5.9*
"Kool-Aid"	40/55	44/29	84	12.6***

Table A-41.--Differences by locality and race in beverage items respondents purchased for their families

Food items	N. La.		S. La.		Total N	X^2 value
	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]		
Coffee	74/52	16/33	69/62	13/26	172	25.4***
Tea	85/60	30/38	64/72	22/30	201	15.0**
Citrus juice	37/30	22/19	21/36	20/15	100	10.0*
Other juice	33/27	19/17	19/32	18/14	89	8.7*
"Kool-Aid"	17/27	26/16	23/30	18/13	84	12.2**
Beer	19/33	12/21	62/39	16/16	109	22.8***
Liquor	10/10	2/ 7	20/12	2/ 5	34	10.0*

Table A-42.--Differences by occupational prestige in beverage items respondents purchased for their families

Food items	Occupational prestige level			Total N	X^2 value
	Low ON/EN[1]	Medium ON/EN[1]	High ON/EN[1]		
Coffee	30/50	89/81	53/41	172	12.1**
Other juice	28/26	31/42	30/21	89	6.4*
Beer	19/32	58/51	32/26	109	7.2*
Liquor	1/10	19/16	14/ 8	34	12.6**

Table A-43.--Differences by locality and race in food combination items respondents considered taboo

Food items	N. La.		S. La.		Total N	X2 value
	White ON/EN[1]	Black ON/EN[1]	White ON/EN[1]	Black ON/EN[1]		
Other than fish & milk	6/10	7/6	6/12	14/5	33	20.7***

Table A-44.--Differences by race in food combination items respondents considered taboo

Food items	White ON/EN[1]	Black ON/EN[1]	Total N	X2 value
Other than fish & milk	12/22	21/1[illegible]	33	13.0***

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THE COCCINELLIDAE OF LOUISIANA

(Insecta: Coleoptera)

Joan B. Chapin

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ABSTRACT

A taxonomic study of the Coccinellidae of Louisiana was undertaken in 1965 to identify the species occurring in the state. Keys and descriptions are provided for the 6 subfamilies, 11 tribes, 27 genera, and 71 species recorded as occurring in the state. Of the species listed, 38 are reported from Louisiana for the first time. Five of these were described as new. Distribution records by parish and dates of seasonal occurrence are given. Fifty-five of the species listed for Louisiana occur also in some states of the upper Mississippi Basin. Brachyacantha quadripunctata Melsheimer, Cryptolaemus montrouzieri Mulsant, and Scymnus (Nephus) intrusus Horn were not collected during this study but are included on the basis of literature reports and previous collection.

THE COCCINELLIDAE OF LOUISIANA (INSECTA: COLEOPTERA)

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INTRODUCTION

Concern about the quality of our environment has stimulated a revival of interest in the predaceous and parasitic familes of insects. The majority of Coccinellidae are of importance as predators on aphids, scale insects, spider mites, and the eggs and larvae of other insects. Only one genus in the Western Hemisphere contains species which are injurious to agricultural crops.

The family was last revised in 1899, and some of the genera which have been studied since then need to be reviewed again now that more material is available. A taxonomic study of the Coccinellidae of Louisiana was undertaken in 1965 to identify the species occurring in the state. Data from specimens collected throughout the state were supplemented by records from the insect collection of the Department of Entomology of Louisiana State University, material borrowed from the U. S. National Museum of Natural History, Washington, D. C., and from the literature.

Keys and descriptions are provided for the 6 subfamilies, 11 tribes, 27 genera, and 71 species recorded as occurring in the state. Of the species listed, 38 are reported from Louisiana for the first time. Five of these were described as new. Distribution records by parish and dates of seasonal occurrence are given. Fifty-five of the species listed for Louisiana occur also in some states of the upper Mississippi Basin.

REVIEW OF THE LITERATURE

Prior to this study, 12 species of Coccinellidae were described from Louisiana. One of these was apparently reported erroneously from the state, one is a *nomen dubium*, and 6 are synonyms of older names (Table 1).

TABLE 1. Species of Coccinellidae described from Louisiana prior to this study.

	Original binomial	Present binomial
1.	*Scymnus terminatus* Say, 1835	*S. terminatus*
2.	*Harmonia notulata* Mulsant, 1850	*Neoharmonia venusta venusta* (Melsheimer, 1847)
3.	*Scymnus creperus* Mulsant, 1850	*S. creperus*
4.	*Scymnus nigrivestis* Mulsant, 1850	*nomen dubium* (Gordon, 1973)
5.	*Thalassa montezumae* Mulsant, 1850	*T. montezumae*
6.	*Naemia fuscilabris* Mulsant, 1866	*Coleomegilla maculata fuscilabris*
7.	*Scymnus amabilis* LeConte, 1852	*S. amabilis*
8.	*Scymnus cinctus* LeConte, 1852	*S. loewii* Mulsant, 1850
9.	*Exochomus guexi* LeConte, 1852	*E. marginipennis* (LeConte, 1824)
10.	*Scymnus circumspectus* Horn, 1895	*S. circumspectus*
11.	*Megilla maculata floridana* Leng, 1903	*C. m. fuscilabris*
12.	*Scymnus ludovicianus* Casey, 1824	*S. flavifrons* Melsheimer, 1847

Mulsant (1850) listed *Thalassa montezumae* as having been collected in New Orleans by Pilate. Crotch (1873) regarded it as doubtfully from the United States. Hubbard (1899) collected the species in Arizona. Following this paper, E. A. Schwarz added that "the Mexican *Thalassa montezumae* had never before been found within the United States, the locality 'New Orleans, La.,' given by Mulsant being evidently erroneous." Leng (1903b) listed it from Tucson and Williams, Arizona. The Coleoptera catalogs by Leng and Korschefsky continue to list Louisiana as one of the localities.

The first listing of Coccinellidae in Louisiana was included in a catalog of the Coleoptera from the region of Lake Pontchartrain by Summers in 1874. He listed 19 species, 11 of which are probably correctly identified, although it is doubtful that *Adalia bipunctata* (Linnaeus) is found that far south. Some of the same species listed by Summers were also reported from New Orleans by Shufeldt (1884) and from Assumption Parish and New Orleans by Townsend (1835).

Hippodamia parenthesis was reported from the Morgan City area by Wickham (1893), an apparent misidentification as the species does not occur here. Hine (1904, 1906) collected five species in Cameron Parish, one of which, *Scymnus caudalis* LeConte, may be misidentified. Rosenfeld (1911) found six lady beetles in a collection of insects and spiders from Spanish moss in Avoyelles Parish. Two of the species listed, *Hyperaspis signata* (Olivier) and *Scymnus collaris* Melsheimer, may have been misidentified.

Cryptolaemus montrouzieri Mulsant and *Rhizobius debilis* Blackburn were reported in south Louisiana by Garrett (1910) and Cressman (1933), respectively, but neither species has been collected in the state since the original report. The first collection of the Mexican bean beetle, *Epilachna varivestis* Mulsant, in Louisiana was reported by Eddy in 1940.

The following workers have reported lady beetles in the Baton Rouge area: Morgan (1897); Tucker (1914); Rosewall (1922); and Floyd (1940). In northeast Louisiana, Glick (1939) listed nine species of coccinellids collected by airplane over Tallulah. Dobzhansky (1931) and Wingo (1952) each list one species. In northwest Louisiana, Newsom and Smith (1949) found six lady beetles common in cotton fields; the identity of one, *Scymnus creperus*, is in doubt.

Five species of lady beetles were used in a study of the effects of Systox on some common predators of the cotton aphid, *Aphis gossypii* Glover, reported by Ahmed, et al. (1954). *Scymnus creperus* and *S. haemorrhous* may be misidentified.

Other listings from Louisiana are reported by Leng (1903b, 1908, 1911), Cressman and Plank (1935), Harrison (1943), Timberlake (1943) and Rees (1947).

METHODS AND MATERIALS

Collection and Preservation of Specimens

Material for this study was obtained from existing collections and from collecting trips made throughout the state. The most profitable time for collecting lady beetles was from early spring to mid-summer, but collections were made throughout the year to determine seasonal occurrence. Specimens were usually collected by sweeping or beating vegetation in cultivated and wooded areas and along roadsides with a sweep net. Some specimens were collected in light traps and boll weevil sex attractant traps.

Specimens were killed and then pinned or preserved in vials of 75% ethyl alcohol. Specimens preserved in alcohol were easily dissected to study the genitalia or other taxonomic characters. When this method was used, however, colors sometimes faded or specimens with delicate integuments became somewhat distorted after drying.

Preparation and Comparison of Genitalia

The following technique was used to dissect and compare the genitalia of male specimens.

Labels were removed from the pin, and the specimen was placed into a beaker of gently bubbling hot water to relax it. Insects affixed to card points were first placed in a watch glass containing ethyl acetate. If the specimen was not free from the card point in about five minutes, it was dropped into a beaker of hot water. After one to three minutes, depending on the size of the specimen, it was removed from the water. A small dissecting needle was inserted at the lateral edge of the hind coxae to separate the abdomen from the thorax. Fine forceps were used to remove the abdomen.

The abdomen was placed in a beaker containing a hot solution of concentrated aqueous potassium hydroxide. The beaker remained on the hot plate for three to five minutes, depending on the size of the specimen. Prolonged exposure to potassium hydroxide causes distortion of the genitalia. The abdomen was then placed in a dish of distilled water for examination. With fine forceps the dorsal membranes of the abdomen were removed and the genitalia lifted out. A stiff camel's hair brush was used to remove excess tissue from the abdomen and genitalia.

Specimens originally on card points were repointed. The abdomen was dried and glued, ventral side up, either upon the same point as the specimen or upon a point beneath it. Labels were repinned. The genitalia were stored in glycerin in a genitalia vial which was pinned at an angle beneath the specimen.

The genitalia of each specimen to be compared were placed separately in a drop of glycerine in a white plastic dish. A small card bearing a number was placed in the dish, and a corresponding number was pinned on the specimen. One dish containing genitalia was placed beneath the microscope, and the genitalia to be compared with it were added or removed from the right to avoid confusion. This enabled a comparison of the genitalia of two specimens from any angle.

Drawings were made with a drawing tube attached to a Wild M 5 steromicroscope. All figures on Plate I are 64X. Figures on Plate II and figures 1 to 11 on Plate III are 68X; figures 12 to 15 on Plate III are 53X. All figures on Plates IV to VII are 9X. The phallobase of the male genitalia was drawn without the trabes.

Identification of Specimens

Specimens were identified by the use of the keys and revisions of Brown (1962), Brown and de Ruette (1962), Casey (1899), Chapin (1946, 1965a), Dobzhansky (1931, 1941), Gordon (1970a, 1970b), Horn (1895), Leng (1903a, 1903b, 1908, and 1911), McKenzie (1936), Sasaji (1968), Timberlake (1943), and Wingo (1952). In addition comparisons were made with type specimens in the U. S. National Museum of Natural History at Washington, D. C., and with type specimens borrowed from Dr. C. W. Wingo of the University of Missouri at Columbia and Dr. W. Y. Watson of Universite Laurentienne, Sudbury, Ontario. Specimens were also borrowed from the Florida State Collection of Arthropods (F.S.C.A.) and Texas A and M University (T.A.M.U.).

FAMILY COCCINELLIDAE WESTWOOD

Coccinellidae Westwood, 1839, p. 395.

Body elongate-oval to round, weakly to strongly convex, pubescent or glabrous. Size 0.8 mm to 18 mm. Elytra not truncate and never distinctly striate. Antennae usually eleven-segmented, but varying from 7 to 11 segments, more or less clubbed. Mandibles simple, bifid or multidentate at apices, with or without basal teeth. Terminal segments of maxillary palpi usually securiform, but sometimes conical, elongate-oval or parallel-sided. Prosternal lobe usually distinctly separating front coxae. Mesepimera reaching middle coxal cavities. Abdomen with 5 or 6 visible sterna, rarely with seventh sternum visible. First abdominal sternum with arcuate postcoxal lines, complete or variously incomplete. Tibial spurs present or absent. Tarsal formula usually cryptotetramerous, but often trimerous, rarely obviously tetramerous. Tarsal claws simple, appendiculate or bifid. Male genitalia with an elongate curved sipho, the true aedeagus, and trilobed phallobase, basically composed of basal lobe and two parameres, sometimes with pair of ventral alae between basal lobe and parameres.

The division of the family into subfamilies and tribes follows the classification proposed by Sasaji (1968).

Key to the subfamilies of the Coccinellidae of Louisiana

1. Apical segments of maxillary palpi conical or elongate-oval; mentum very narrowly joined to submentum . . . .Sticholotinae Sasaji
   Apical segments of maxillary palpi strongly divergent apically, nearly parallel-sided or rarely slightly convergent apically; mentum usually not very narrowly articulated with submentum. . . . 2
2. Clypeus strongly expanded laterally, concealing antennal bases and subdividing eyes . . . . Chilocorinae Sasaji
   Clypeus not as above 3
3. Antennae relatively short, at most two-thirds as long as head width; apical segments of maxillary palpi usually nearly parallel-sided, never strongly divergent apically; middle coxal cavities usually broadly separated. . . . . .Scymninae Sasaji
   Antennae relatively long, at least half as long as width of head, usually longer than two-thirds of that; terminal segments of maxillary palpi usually strongly divergent apically; middle coxal cavities usually narrowly separated. 4
4. Dorsal surface glabrous. . . . . .Coccinellinae Ganglbauer
   Dorsal surface pubescent 5
5. Body strongly convex, 5 mm or more in length; antennae always eleven-segmented; mandibles with multidenticulate tips and without basal teeth; abdomen always with 6 visible sterna; tarsi always cryptotetramerous. . . . . Epilachninae Ganglbauer
   Body weakly convex, less than 5 mm in length; antennae eight- to eleven-segmented; mandibles with bifid tips and basal teeth; abdomen with 5 or 6 visible sterna; tarsi obviously tetramerous, cryptotetramerous or trimerous . . . . Coccidulinae Sasaji

Subfamily Sticholotinae Sasaji

Sticholotinae Sasaji, 1968, p. 19.

Body minute or small in size. Head capsule sometimes projecting anteriorly. Antennae usually inserted more or less dorsally, rarely laterally. Mandibles simple or bifid at tips. Apical segments of maxillary palpi conical or elongate-oval. Mentum and submentum narrowly joined. Middle coxal cavities broadly separated by compact and broad articulation of mesosternum and metasternum. Tarsi usually cryptotetramerous, rarely trimerous.

This subfamily contains four tribes, two of which occur in the Western Hemisphere.

Key to the tribes of the Sticholotinae of Louisiana

1. Antennal club composed of single segment; prosternum strongly lobed in front completely concealing mouthparts . . . . .Serangiini Blackwelder
   Antennal club composed of more than one segment; prosternum not covering mouthparts. . . . . .Sticholotini Weise

Tribe Serangiini Blackwelder

Serangiini Blackwelder, 1945, p. 450.

Dorsal surface strongly convex, shining, very sparsely pubescent. Antennae eight- or nine-segmented, each club composed of a single elongate segment. Terminal segments of maxillary palpi elongate-oval. Prosternum strongly lobed in front, completely concealing mouthparts. Ventral surface with grooves for reception of femora. Femora very broad and flat, concealing tibiae when legs are retracted. Abdomen composed of 5 visible sterna, apical sternum longer than 3 preceding.

One genus occurs in the United States.

Genus *Delphastus* Casey

Delphastus Casey, 1899, p. 111.

Body elongate-oval, compact, glabrous, sparsely pubescent. Antennae nine-segmented, clubs each composed of one elongate segment. Pronotum completely margined, obliquely so at apical angles. Prosternum strongly lobed in front, concealing mouthparts, notched on each side for reception of antennae. Ventral surface of body with deep grooves for reception of legs; epipleura notched for reception of femoral tips. Legs with coxae widely separated; anterior femora broad and flat, concealing tibiae and tarsi; middle and hind tibiae angulate externally. Abdomen with 5 visible sterna, first and fifth longer than rest.

The genus was recently reviewed by Gordon (1970b) who listed twelve species, one of which occurs in Louisiana.

Delphastus pusillus (LeConte)

Oeneis pusilla LeConte, 1852, p. 135.

Head yellow in male, brownish black in female; slightly pubescent with a band of coarse punctures across vertex. Pronotum with fine sparse punctures, slightly pubescent, black, lateral margins yellow in male. Elytra black, appearing impunctate, but finely sparsely punctate, slightly pubescent at base and apex. Ventral surface black, prosternum and legs yellow in male, darker in female. Prosternal lobe impunctate; first 4 abdominal sterna finely sparsely punctate, fifth sternum finely densely punctate. Length, 1.4-1.6 mm; width, 1.1-1.3 mm.

Specimens examined: 44 were collected from April 11 to October 21. Some specimens were collected on gardenia infested with whitefly.

Distribution records: Avoyelles, Caddo, Catahoula, Claiborne, East Baton Rouge, East Feliciana, Franklin, Grant, Ouachita, Pointe Coupee, Rapides, Red River, Sabine, St. Helena, and West Feliciana parishes.

Tribe Sticholotini Weise

Sticholotini Weise, 1900, p. 430.

Body minute to small, dorsum glabrous or uniformly pubescent. Antennae consisting of 7 to 11 segments; antennal clubs with 2 or more segments. Terminal segments of maxillary palpi usually conical. Prosternum broad, quadrate, not lobed in front, mouthparts visible. Abdomen composed of 5 or 6 visible sterna, 2 basal sterna usually not fused.

Leng (1920) erected the tribe Microweiseini for the single genus Microweisea. The genus was placed in the tribe Pharini Casey by Pope (1962). Sasaji (1968) pointed out that the tribal name Pharini cannot be used because the generic name Pharus is a homonym; therefore, the oldest valid name for the group is Sticholotini.

Four North American genera are presently included in this tribe, one of which is found in Louisiana.

Genus Microweisea Cockerell

Microweisea Cockerell, 1903, p. 38.

Body elongate-oval, glabrous, with a few short hairs. Head with clypeus abruptly expanded in width in front of antennal sockets. Antennae ten-segmented; clubs three-segmented. Pronotum with oblique lines across anterior angles. Apical segments of maxillary palpi conical. Prosternum with anterior margin slightly lobed. Abdomen with 6 visible sterna. Postcoxal lines on first abdominal sternum incomplete, nearly reaching hind margin, not extending laterally.

Horn (1895) moved the North American species from the genus Pentilia Mulsant and placed them in Smilia Weise. Cockerell (1903) discovered that Smilia was preoccupied and in 1900 proposed Epismilia to replace it, only to find that name had also been used before at the generic level. He, therefore, proposed Microweisea to replace Epismilia. The name Pseudoweisea proposed by Schwarz (1904) is a misquotation of Cockerell's name. Gordon (1970a) reviewed the genus and presented a key to the five species, one of which has been collected in Louisiana.

Microweisea misella (LeConte)

Pentilia misella Leconte, 1878, p. 400.

Body entirely black in color. Head alutaceous, nearly impunctate. Pronotum alutaceous, finely punctured. Elytra shining, coarsely unevenly punctured. Abdominal sterna alutaceous, impunctate. Length, 0.9-1.1 mm; width, 0.6-0.8 mm.

Specimens examined: 50 were collected from January 27 to December 30, but none were collected in September and November.

Distribution records: Cameron, DeSoto, East Baton Rouge, Livingston, Ouachita, Sabine, Tangipahoa, and West Feliciana parishes.

Discussion: Morgan (1897) reported that a species of Microweisea, which was probably M. misella, was found feeding on red spider on Citrus trifoliata L. Cressman and Plank (1935) listed this species as a predator of the camphor scale, Pseudaonidia duplex (Cockerell). Many specimens were collected on Melia azedarach L. infested with a bark scale.

Subfamily Scymninae Sasaji

Scymninae Sasji, 1968, p. 23.

Dorsal surface pubescent, but glabrous in the Hyperaspini and apparently so in some genera of Scymnillini. Antennae usually very short, at most about two-thirds as long as head width. Terminal segments of maxillary palpi not strongly securiform, usually nearly parallel-sided. Middle coxae comparatively broadly separated. Elytral epipleura very narrow and rather short. Femora nearly cylindrical, rather stout, sometimes flat. Tarsi cryptotetramerous or trimerous.

Sasaji included five tribes in this subfamily.

Key to the tribes of the Scymninae of Louisiana

1. Dorsal surface glabrous or apparently so 2
   Dorsal surface obviously pubescent 3
2. Dorsal surface glabrous; female with 6 abdominal sterna, male with seven, last very small . . . . Hyperaspini Costa
   Head and thorax sparsely pubescent; abdomen with 5 sterna in both sexes. . . . . Scymnillini Casey
3. Terminal segments of maxillary palpi slightly convergent apically with apices truncate; anterior margin of prosternum convex anteriorly, partially concealing mouthparts, prosternal carinae absent . . . . Stethorini Dobzhansky
   Terminal segments of maxillary palpi parallel-sided or slightly divergent apically; anterior margin of prosternum straight or slightly concave, or in Cryptolaemus, convex and covering mouthparts; prosternal carinae present or absent . . .Scymnini Costa

Tribe Stethorini Dobzhansky

Stethorini Dobzhansky, 1924, p. 20.

Body very small. Dorsum pubescent. Antennae eleven-segmented. Terminal segments of maxillary palpi slightly convergent apically with truncate apices. Prosternum roundly convex anteriorly, partly concealing mouthparts, prosternal lobe without carinae. Inner side of mesepimeron very short. Abdomen with 6 visible sterna.

This tribe contains a single genus.

Genus Stethorus Weise

Stethorus Weise, 1885, p. 65.

Body small, elongate-oval, pubescent. Eyes large, moderately coarsely faceted. Antennae short, eleven-segmented, inserted between eyes and lateral margins of clypeus; antennal bases exposed, but clypeus not emarginate around them. Clypeus short before eyes, truncate with rounded angles. Mandibles each with subapical tooth. Apical segments of maxillary palpi oblong, obliquely truncate and narrower toward apices. Prosternum convex medially, without carinae, extended forward in broad arc so as to partly hide mouthparts. Abdomen with 6 visible sterna, suture between first 2 sterna faint at middle. Postcoxal lines on first abdominal sternum complete, but of variable length. Tarsi trimerous. Tarsal claws bifid.

There are seven species in America north of Mexico according to Leng (1920), Brown (1950), and Hall and Fleshner (1958).

Key to the species of *Stethorus* of Louisiana

1. Postcoxal lines on first abdominal sternum not surpassing middle of segment . . . . *punctum* (LeConte)
   Postcoxal lines on first abdominal sternum reaching almost to posterior margin . . . . *utilis* (Horn)

Stethorus punctum (LeConte)

Scymnus punctum LeConte, 1852, p. 141.

Head black, antennae and mouthparts yellowish. Pronotum black, finely evenly punctate. Elytra black, more coarsely punctured than pronotum. Ventral surface black. Postcoxal lines on first abdominal sternum complete, short, not surpassing middle of sternum. Male phallobase figured on Pl. III, Fig. 10. Legs yellow; femora dark brown, tips pale. Length 1.3 mm; width, 0.8-0.9 mm.

Specimens examined: 24 were collected from May 2 to June 4 and from October 4 to November 21 on azalea, magnolia, and *Quercus nigra* L. infested with spider mites.

Distribution records: East Baton Rouge, Ouachita, Rapides, and Sabine parishes.

Stethorus utilis (Horn)

Scymnus utilis Horn, 1895, p. 107.

Head black, antennae and mouthparts yellowish. Pronotum black, finely evenly punctate. Elytra black, more coarsely punctured than pronotum. Ventral surface black. Postcoxal lines of first abdominal sternum complete, reaching almost to posterior margin. Male phallobase figured on Pl. III, Fig. 11. Legs yellow; femora dark brown, tips pale. Length, 1.1-1.3 mm; width, 0.8-0.9 mm.

Specimens examined: 119 were collected from February 12 to November 21, but none were collected in August. Most of the specimens were collected on azalea, magnolia, and *Quercus nigra* L. infested with spider mites.

Distribution records: East Baton Rouge, Pointe Coupee, Sabine, Tangipahoa, and West Feliciana parishes.

Discussion: This species is very similar to S. punctum but differs in the length of the postcoxal lines which extend to the posterior margin of the first abdominal sternum.

Tribe Scymini Costa

Scymnini Costa, 1849, p. 9.

Dorsum pubescent. Antennae nine-to eleven-segmented, moderately clubbed, usually relatively short. Eyes usually moderate in size with or without postantennal emarginations. Terminal segments of maxillary palpi parallel-sided or slightly divergent apically. Anterior margin of prosternum flat or slightly concave, with or without prosternal carinae; except in Cryptolaemus in which it is convex anteriorly completely concealing mouthparts. Inner side of mesepimeron rather long. Elytral epipleura narrow, horizontal and without foveae. Abdomen with 6 visible sterna. Tarsi cryptotetramerous or trimerous. Male genitalia symmetrical or asymmetrical, simple or complex.

There are presently eight genera in the tribe.

Key to the genera of the Scymnini of Louisiana

1. Prosternum extended forward covering mouthparts and antennae in repose . . . . .Cryptolaemus Mulsant
Prosternum not extended forward covering mouthparts. 2
2. Head in repose covering prosternum and anterior coxae; antennae with 2 basal segments large, compressed; head greatly extended anteriorly in front of eyes. . . . . Nephaspis Casey
Head in repose not covering prosternum and anterior coxae; antennae with two basal segments not large and compressed; head slightly extended anteriorly in front of eyes . . . . .Scymnus Kugelann

Genus Scymnus Kugelann

Scymnus Kugelann, 1794, p. 545.

Body oval to elongate-oval, dorsal surface pubescent. Antennae eleven-segmented. Terminal segments of maxillary palpi parallel-sided, apical margins strongly oblique. Prosternum not extended anteriorly, with or without prosternal carinae. Abdomen with 6 visible sterna. Postcoxal lines on first abdominal sternum complete or incomplete, varying subgenerically. Elytral epipleura narrow, horizontal, not foveate for reception of femoral apices. Tibial spurs absent. Tarsi four-segmented, third very small or sometimes absent. Tarsal claws variable. Male genitalia simple or complex; symmetrical or asymmetrical.

This genus has more species than any other genus in the United States. It is being revised by Robert D. Gordon who has kindly made available to me the current names to be used for Louisiana species.

Key to the subgenera of *Scymnus* of Louisiana

1. Postcoxal lines on first abdominal sternum recurved toward base of abdomen 2
Postcoxal lines not recurved toward base of abdomen. 3
2. Postcoxal lines complete, reaching base of first abdominal sternum . . . .*Pullus* Mulsant
Postcoxal lines incomplete, recurved toward, but not reaching base of first abdominal sternum . . . .*Scymnus* s. str. Kugelann
3. Postcoxal lines joining posterior margin of first abdominal sternum. . . . .*Diomus* Mulsant
Postcoxal lines not joining posterior margin of first abdominal sternum, but continuing laterally parallel to it . . .*Nephus* Mulsant

Subgenus *Scymnus* s. str. Kugelann

Scymnus Kugelann, 1794, p. 545.

Prosternal lobe with 2 carinae. Postcoxal lines on first abdominal sternum not reaching posterior margin, recurved toward, but not reaching base of abdomen. Fifth abdominal sternum of male usually emarginate.

Five species have been described from eastern North America.

Key to the species of the subgenus *Scymnus* s. str. of Louisiana

1. Elytra ferrugineous with numerous small black spots . . . . *nebulosus* LeConte
Elytra black 2
2. Each elytron with large red spot in front of middle . . . .*circumspectus* Horn
Elytra with apical edge reddish yellow 3
3. Parameres triangular in shape (Pl. I, Fig. 5); sipho with fishhook-like projection at apex. . . . .*paracanus* Chapin
Parameres oblong-oval (Pl. I, Fig. 3), scarcely broader at bases than at apices 4
4. Sipho without fishhook-like projection at apex; basal lobe narrowly triangular . . . . *indianensis* Weise
Sipho with fishhook-like projection at apex; basal lobe broad at base, gradually rounding to point at apex. . . . . . *apicanus* Chapin

Scymnus (*Scymnus*) *circumspectus* Horn

Scymnus circumspectus Horn, 1895, p. 96.

Head black, mouthparts pale. Pronotum black. Elytra black; each elytron with large red spot just before middle. Ventral surface black. First abdominal sternum of males with median carinae, fifth emarginate and impressed with sixth to form a shallow fovea. Legs with femora black, tibiae and tarsi reddish brown. Male phallobase figured on Pl. I, Fig. 6. Length, 2.4-2.6 mm; width, 1.9 mm.

Specimens examined: 4 were collected from March 27 to June 29, but none were collected in April.

Distribution records: Caddo (N.M.N.H.), Livingston, Natchitoches (N.M.N.H.), and Ouachita parishes.

Discussion: Horn described this species from Louisiana and Tennessee.

Scymnus (*Scymnus*) *indianensis* Weise

Scymnus rusticus Casey, 1899, p. 154 (Preoccupied).

Scymnus indianensis Weise, 1929, p. 33.

Head reddish yellow. Pronotum reddish yellow with median arcuate black spot at base occupying most of length, or black with lateral margins pale. Elytra black, apical edge reddish yellow. Prosternum black, pale laterally; prosternal carinae complete to anterior margin, converging slightly. Mesosternum and metasternum black. Abdomen with first 2 or 3 sterna black, pale laterally; remainder reddish yellow. Fifth sternum of male slightly emarginate. Legs reddish yellow. Male phallobase (Pl. I, Fig. 1) with basal lobe and parameres almost equal in length; basal lobe narrowly triangular; each paramere oblong-oval, scarcely broader at base than at apex, fringed with hair except at basal half of dorsal edge; sipho without fishhook-like projection near tip. Length, 1.9-2.1 mm; width, 1.4-1.6 mm.

Specimens examined: 6 males were collected from May 10 to July 15, but none were collected in June.

Distribution records: Ascension, East Baton Rouge, East Feliciana, and West Feliciana parishes.

Discussion: This species was thought to be *S. americanus* Mulsant until recent work by R. D. Gordon separated the two (Gordon, 1972).

Scymnus (*Scymnus*) *apicanus* Chapin

Scymnus (*Scymnus*) *apicanus* Chapin, 1973, p. 1071.

Head, mouthparts, and antennae reddish yellow. Pronotum reddish yellow with median arcuate black spot at base which extends anteriorly for four-fifths the length. Elytra black, narrowly reddish yellow apically. Prosternum black at middle, reddish yellow laterally; prosternal carinae convergent, disappearing before anterior margin. Mesosternum and metasternum black. Abdomen with first 3 sterna black medially, pale laterally, remainder reddish yellow; fifth sternum emarginate at apex. Legs reddish yellow. Male phallobase (Pl. I, Fig. 2, 3) with basal lobe a little longer than parameres, broad at base, gradually rounding to a point at apex; each paramere oblong-oval, scarcely broader at base than apex, fringed with hair except at basal half of dorsal edge; sipho with fishhook-like projection near tip. Length, 2.1-2.6 mm; width, 1.6-1.9 mm.

Specimens examined: 14 males were collected from April 27 to June 26.

Distribution records: Ascension and Plaquemines parishes.

Discussion: This species closely resembles S. indianensis. It differs in the following characters: it is larger and the fifth abdominal sternum of males is more deeply emarginate; the male genitalia are larger with the basal lobe a pointed oval instead of a narrow triangle; and the sipho has a fishhook-like projection near the tip.

Scymnus (Scymnus) paracanus Chapin

Scymnus (Scymnus) paracanus Chapin, 1973, p. 1071.

Head, mouthparts, and antennae reddish yellow. Pronotum reddish yellow with median arcuate black spot at base which extends anteriorly for three-fourths the length. Elytra black, apical edge broadly reddish yellow. Prosternum reddish yellow, darker between coxae; prosternal carinae convergent, fading out toward anterior margin. Mesosternum and metasternum black. Abdominal sterna reddish brown, first one darker; fifth sternum emarginate at apex. Legs reddish yellow. Male phallobase (Pl. I, Fig. 4, 5) with basal lobe longer than parameres, parallel-sided for basal two-thirds, narrowing to a blunt point; each paramere triangular in shape, broader at base than apex, fringed with hair except along basal half of dorsal edge; sipho with fishhook-like projection near apex. Length, 2.4-2.8 mm; width, 1.8-1.9 mm.

Specimens examined: 3 males were collected May 6 and July 25. One of these was reared from a larva feeding on cotton aphids.

Distribution records: Claiborne and Webster parishes.

Discussion: This species differs from S. indianensis and S. apicanus in the shape of the parameres and the basal lobe of the male genitalia.

Scymnus (Scymnus) nebulosus LeConte

Scymnus nebulosus LeConte, 1852, p. 137.

Head ferrugineous. Pronotum ferrugineous with indefinite median brown spot at base. Elytra ferrugineous with irregular black spots. Prosternum black, lateral margins ferrugineous; prosternal carinae complete to anterior margin, converging slightly. Mesosternum and metasternum black. Abdominal sterna brown at base, paler apically. Legs ferrugineous, femora darker. Male phallobase figured on Pl. I, Fig. 7, 8. Length, 2.3 mm; width, 1.6 mm.

Specimens examined: A single male was collected in Natchitoches, Louisiana, March 28, 1907, on Crataegus sp. by Cushman and Pierce (N.M.N.H.).

Discussion: Since S. nebulosus was described from California and no specimens were collected during this study, it is possible that this species is not native to Louisiana.

Subgenus Pullus Mulsant

Pullus Mulsant, 1846, p. 241.

Prosternal lobe with 2 carinae. Postcoxal lines on first abdominal sternum forming complete arcs which are shorter than the sternum; first abdominal sternum of male may or may not be modified at the middle; fifth sternum of male usually emarginate. Male genitalia symmetrical or asymmetrical, with or without ventral alae.

The subgenus Pullus is the largest and most difficult group because of the similarity of species. Color patterns vary intraspecifically and frequently several species share the same color pattern. Casey (1899) was the last to review the whole group. Wingo (1952) studied 24 species of the upper Mississippi basin and described eight new species. He used the male genitalia to separate species in addition to using the characters of the first and fifth abdominal sterna of males more extensively than had previous authors. Fourteen species of Pullus have been collected in Louisiana; all but three occur in the upper Mississippi basin.

Mulsant (1850) described S. nigrivestis from New Orleans. The type cannot be located, and the name must be considered a nomen dubium (Gordon, 1973).

Key to the species of the subgenus Pullus of Louisiana

1. Lateral margins of body reddish yellow above; pronotum with basal black spot confluent with triangular black area along elytral suture; first abdominal sternum of male with median oval depressed area . . . . .loewii Mulsant

Body black above or with pale areas on margins of pronotum and apex of elytra 2

2. Apex of elytra with broad pale area covering at least one-fifth of length. 3

Apex of elytra black or narrowly pale. 7

3. First abdominal sternum of male with median glabrous area surrounded by dense punctures and pubescence 4

First abdominal sternum not so modified. 5

4. Apical pale area occupying about one-fourth of elytral length; elongate-oval beetles; male genitalia with basal lobe and parameres subequal in length, ventral alae lacking . . . .*securus* Chapin

Apical pale area occupying more than two-fifths of elytral length; broadly oval beetles; male genitalia with basal lobe longer than parameres, ventral alae present. . . . . *brullei* Mulsant

5. Apical pale area of elytra occupying one-fifth of length; first abdominal sternum of male depressed at middle with minute glabrous area at posterior margin not surrounded by dense pubescence; fifth and sixth sterna with shallow fovea. 6

Apical pale area of elytra occupying one-third to two-fifths of length; first abdominal sternum of male unmodified; sixth deeply emarginate with two ventrally produced hooks . . . *rubricaudus* Casey

6. Basal lobe of male genitalia with large downward projecting hook on upper right ventral surface; dorsally, 2 laterally curved processes at middle of base. . . . . *louisianae* Chapin

Basal lobe without large downward projecting hook on upper right ventral surface; dorsally, 2 processes located each side of middle . . . . *fraternus* LeConte

7. Pronotum entirely black or black with anterior angles pale 8

Pronotum reddish yellow or reddish yellow with median black spot of variable size at base 9

8. Less than 2 mm long; oval; male with large spade-shaped median glabrous area on first abdominal sternum; male genitalia with basal lobe shorter than ventral alae and parameres . . .*compar* Casey

More than 2 mm long; rounded; male with median glabrous area of first abdominal sternum triangular in shape; male genitalia with basal lobe longer than parameres and shorter than ventral alae . . . .*tenebrosus* Mulsant

9. Pronotum entirely reddish yellow; male genitalia with basal lobe longer than parameres which are thick and heavily sclerotized; ventral alae absent. . . . .*cervicalis* Mulsant

Pronotum reddish yellow with median black spot of variable size at base; sometimes greatly reduced; male genitalia with ventral alae 10

10. Basal lobe longer than ventral alae, with 2 raised lines uniting at apical third; parameres less than half the length of ventral alae . . . .*creperus* Mulsant

Basal lobe as long as or shorter than ventral alae 11

11. Apex of basal lobe with pronounced ventrally produced hook . . . . *uncus* Wingo

Apex of basal lobe without such a hood 12

12. Ventral alae attached at base of basal lobe; basal lobe longer than parameres and shorter than ventral alae with ventral ridges rising to a point scarcely curved dorsally, above oval dorsal surface. . . . . *socer* LeConte

Ventral alae attached along basal two-thirds of basal lobe 13

13. Basal lobe nearly equal in length to ventral margins of basal piece; ventral alae narrow, neither rolled ventrally nor expanded dorsally at tips . . . .*natchezianus* of Wingo, 1952, not Casey, 1899

Basal lobe longer than the length of the ventral margins of basal piece; ventral alae rolled ventrally and expanded dorsally at tips . . . . *puncticollis* LeConte

Scymnus (*Pullus*) *louisianae* Chapin

Scymnus (*Pullus*) *louisianae* Chapin, 1973, p. 1071.

Head, mouthparts, and antennae reddish yellow. Pronotum reddish yellow with median arcuate black spot at base which reaches anteriorly for five-eighths or more of the length. Elytra black with slightly arcuate apical pale area on each elytron which occupies about one-fifth the length of the elytra. Prosternum reddish yellow, darker between coxae. Mesosternum and metasternum black. Abdomen with first 2 sterna black, second pale laterally; remainder of sterna reddish yellow. First abdominal sternum depressed at middle; with minute glabrous area at posterior margin; fifth sternum apically impressed with sixth to form a shallow fovea; sixth emarginate apically. Legs reddish yellow. Male phallobase (Pl. I, Fig. 11, 12) with basal lobe longer than parameres. Basal lobe asymmetrical with a dorsally curved point at apex; right side with two ventral lobes, the upper very large and bearing a downward projecting hook; left side lobed at basal half; dorsal surface with a projection from apex to middle; base with 2 laterally curved processes at middle. Each paramere narrow at base and apex, tip bluntly rounded with 2 tufts of hair, a few short fine hairs on dorsal side, a longer tuft on ventral side. Ventral alae absent. Length, 2.1-2.4 mm; width, 1.4-1.8 mm.

Specimens examined: 73 males were collected from May 17 to October 11.

Distribution records: Caddo, Concordia, DeSoto, East Baton Rouge, East Feliciana, Franklin, Iberville, Natchitoches, Ouachita, Rapides, Sabine, St. Martin, Tangipahoa, and Webster parishes.

Discussion: Specimens were collected on *Lactuca canadensis* L. infested with *Dactynotus pseudoambrosiae* Oliver and crapemyrtle and pyracantha infested with aphids.

This species is very similar to *S. fraternus*. The basal lobes of both are asymmetrical, but in *S. fraternus* the large ventral lobe on the right side ends in a blunt point and the two processes at the base on the dorsal surface are situated laterally.

Scymnus (*Pullus*) *fraternus* LeConte

Scymnus fraternus LeConte, 1852, p. 138.

Head, mouthparts, and antennae reddish yellow. Pronotum reddish yellow with median arcuate black spot at base which extends almost to anterior margin. Elytra black with slightly arcuate apical pale area on each elytron which occupies about one-fifth the length of the elytra. Prosternum reddish yellow, darker between coxae. Mesosternum and metasternum black. Abdomen with first 2 sterna black, second pale laterally; remainder of sterna reddish yellow. First abdominal sternum depressed at middle, with minute glabrous area at posterior margin; fifth sternum apically impressed with sixth to form a shallow fovea; fifth and sixth slightly emarginate apically. Legs reddish yellow. Male phallobase figured on Pl. I, Fig. 13, 14. Length, 2.3 mm; width, 1.6-1.8 mm.

Specimens examined: 4 males were collected from July 9 to August 3 in West Feliciana Parish.

Discussion: The differences between this species and _S_. _louisianae_ have been discussed under the latter species. Specimens of _S_. _fraternus_ were also examined from New York, New Jersey, North Carolina, and Tennessee indicating that distributions of the two species overlap.

Scymnus (_Pullus_) _rubricaudus_ Casey

Scymnus _rubricauda_ Casey, 1899, p. 141.

Head reddish yellow. Pronotum black, anterior margin, anterior angles or lateral margins reddish yellow; one specimen with pronotum reddish yellow with indefinite arcuate black spot in front of scutellum. Elytra black; each elytron with arcuate apical pale area extending anteriorly one-third to two-fifths the length. Prosternum black, lateral margins reddish yellow. Mesosternum and metasternum black. Abdomen with first 2 abdominal sterna black, pale laterally; remainder of sterna reddish yellow. First abdominal sternum of male unmodified; fifth shallowly emarginate; sixth deeply emarginate with two ventrally produced hooks. Legs reddish yellow. Male phallobase (Pl. II, Fig. 8) with basal lobe longer than parameres; basal lobe broad at base tapering to point from apical third with 2 pairs of ventrally produced lobes; parameres with short tufts of hair at apices; ventral alae absent. Length, 1.6-1.9 mm; width, 1.1-1.4 mm.

Specimens examined: 7 were collected May 21, June 2, and October 5.

Distribution records: Caddo, Rapides, and West Feliciana parishes.

Discussion: Wingo (1952) synonymized _S_. _texanus_ Casey and _S_. _chromopyga_ Casey with _S_. _rubricaudus_. The male genitalia of the type specimens are identical.

Scymnus (_Pullus_) _securus_ Chapin

Scymnus (_Pullus_) _securus_ Chapin, 1973, p. 1072.

Head, mouthparts and antennae reddish yellow. Pronotum reddish yellow with median arcuate black spot at base extending anteriorly for most of length or black with anterior margins, anterior angles or lateral margins reddish yellow. Elytra black; each elytron with arcuate apical pale area occupying one fourth the length. Prosternum reddish brown or black, lateral margins reddish yellow. Mesosternum and metasternum black. Abdomen with first 2 abdominal sterna black, pale laterally; remainder reddish yellow. First abdominal sternum with minute median glabrous area surrounded by a large patch of dense punctures and pubescence; fifth widely emarginate at apex and impressed with sixth to form a shallow fovea; sixth narrowly emarginate at apex. Legs reddish yellow. Male phallobase (Pl. I, Fig. 9, 10) with basal lobe and parameres subequal in length; basal lobe broad at base and pointed at apex with broad lobes ventrally; parameres with pointed tufts of hair at apices; ventral alae absent. Length, 1.9-2.3 mm; width, 1.3-1.6 mm.

Specimens examined: 31 were collected from May 29 to October 23.

Distribution records: Cameron, St. Tammany, and Tangipahoa parishes.

Discussion: This species resembles S. rubricaudus. The male of S. securus has a median patch of dense punctures and pubescence on the first abdominal sternum and lacks the ventrally produced hooks of the sixth sternum. The specimens from Cameron Parish were collected in a grassy coastal marsh.

Scymnus (Pullus) brullei Mulsant

Scymnus brullei Mulsant, 1850, p. 984.

Head black basally, yellow from anterior margin of frons distally. Pronotum black or with anterior angles reddish brown. Elytra black with sharply arcuate reddish yellow apical spot on each elytron extending from two-fifths to more than half the length. Prosternum black with lateral margins pale. Mesosternum and metasternum black. First 2 abdominal sterna black, second pale laterally; remainder reddish yellow. First abdominal sternum of male depressed at middle with median glabrous area, variable in extent, surrounded by dense punctures and pubescence; fifth broadly emarginate. Legs reddish yellow. Male phallobase (Pl. II, Fig. 11) with basal lobe longer than parameres and ventral alae; basal lobe pointed at apex, narrowed at about the middle, flattened dorsally, grooved laterally, ventral ridges expanded at apical half like a hood; membranes connecting ventral alae to basal lobe narrow, bluntly pointed and lightly sclerotized ventrally; ventral alae almost as long as basal lobe; parameres shorter than ventral alae with tufts of hair at apices. Length, 2.3-2.4 mm; width, 1.6-1.8 mm.

Specimens examined: 5 were collected from May 5 to June 21. One was reared from a larva feeding on Hysteroneura setariae (Thomas) on Prunus sp.

Distribution records: Ouachita, Tensas, and West Feliciana parishes.

Discussion: Scymnus brullei, which was described from Florida, is one of several species with similar color patterns and male genitalia. Five other specimens with identical genitalia have been examined from Texas and Michigan. Their color pattern varies, and in one specimen, the head, lateral margins of the pronotum, and an apical area extending almost to the humeral angles are reddish yellow.

The species Wingo (1952) described as S. brullei is not conspecific with Louisiana specimens. In that species the membranes connecting the basal lobe and ventral alae appear bilobed at the apices with the dorsal of the two lobes being a little longer; each paramere has a dorsal row of hair at the basal half and a tuft of hair at the apex. Wingo reported that this species was very variable in pronotal and elytral markings. He examined specimens from every state of the upper Mississippi basin. The author has also examined a specimen from Maryland and one from Kansas.

Species in this group have similar characters on the first and fifth abdominal sterna which serve to separate them from other species which they resemble in color pattern.

Scymnus (Pullus) loewii Mulsant

Scymnus loewii Mulsant, 1850, p. 980.

Head reddish yellow. Pronotum reddish yellow with median arcuate black spot at base extending anteriorly for three-fourths the length. Elytra reddish yellow laterally with central triangular black spot, wider than, but confluent with the one on the pronotum, decreasing to point before apex of elytra; sometimes with piceous streak on lateral edges behind middle. Prosternum reddish yellow, black between coxae. Mesosternum and metasternum black. Abdominal sterna black or with last 4 sterna reddish brown. First abdominal sternum of male with median oval depressed area with pubescence no longer than that of surrounding areas, fifth sternum not emarginate, sixth with small fovea. Legs reddish yellow, femora sometimes darker. Male phallobase (Pl. II, Fig. 1) with basal lobe longer than parameres, widest at base and tapering to point at apical third with 2 ventral lobes; parameres with tufts of hair at apices extending to tip of basal lobe; ventral alae lacking. Length, 1.9-2.3 mm; width, 1.3-1.6 mm.

Specimens examined: 81 were collected from April 1 to November 17. This is a common species in the state. The following host associations were noted: Solidago sp. infested with Dactynotus ambrosiae (Thomas); Verbesina sp. infested with Dactynotus verbesinae (Boudreaux); and Betula nigra L. infested with Calaphis betulella Walsh.

Distribution records: Specimens were collected in 35 parishes, and the species probably occurs throughout the state.

Discussion: Scymnus loewii was described by Mulsant in 1850 from Mexico. In 1852 LeConte described S. cinctus from New Orleans and said it differed from S. loewii by its entirely yellow feet.

Horn (1895) regarded the differences between *S. cinctus* and *S. loewii* as being of an evanescent nature. He listed the distribution of the former as being from New Orleans through Texas and westward to California. Gorham (1897) agreed with Horn and listed *S. cinctus* as a synonym of *S. loewii*. Korschefsky (1931) listed the two species separately giving the same distribution for each. Chapin (1965b) regarded *S. cinctus* as a synonym of *S. loewii*.

Wingo (1952) stated that this species may be confused with similarly marked pale forms which he identified as *S. brullei*. The male of *S. loewii* is distinguished from other species by the median oval depressed area without long pubescence on the first abdominal sternum.

Two specimens differ from the normal color pattern in having a triangular red spot on each elytron which extends from the apex to the middle of the length. The male genitalia are identical to those of other males of the species.

Scymnus (*Pullus*) *cervicalis* Mulsant

Scymnus cervicalis Mulsant, 1850, p. 984.

Head and pronotum reddish yellow. Elytra black, apex narrowly edged with reddish yellow. Prosternum reddish yellow. Mesosternum and metasternum black. Abdomen with first sternum black, next 3 sterna black in middle and pale laterally, last two generally pale. First abdominal sternum of male flattened at middle with small glabrous area at margin which is almost obsolete in some specimens; pubescence all of same length; fifth sternum emarginate and impressed with sixth to form a shallow fovea. Legs reddish yellow. Male phallobase (Pl. II, Fig. 9) with basal lobe rising to point above parameres; parameres thick, heavily sclerotized, with hairs laterally on apical halves which are almost as long as the basal lobe; ventral alae absent. Length, 1.8-1.9 mm; width, 1.1-1.4 mm.

Specimens examined: 46 were collected from March 28 to May 29 and from September 17 to November 21. Most of them were collected on *Quercus michauxii* Nutt.

Distribution records: Catahoula, East Baton Rouge, Ouachita, Rapides, Tangipahoa, and West Feliciana parishes.

Discussion: Wingo (1952) mistakenly reported that ventral alae were present; he also said the first abdominal sternum was not modified, but most Louisiana specimens have a small glabrous area at the posterior margin.

Scymnus (*Pullus*) *creperus* Mulsant

Scymnus creperus Mulsant, 1850, p. 985.

Head reddish yellow. Pronotum reddish yellow with triangular black spot at base which extends anteriorly to middle or a little beyond. Elytra black, narrowly edged with reddish yellow at apex. Prosternum reddish yellow, black between coxae. Mesosternum and metasternum black. First 2 abdominal sterna black, second pale laterally; remainder of sterna reddish yellow, darker at middle. First abdominal sternum of male convex at middle with small median glabrous area at posterior margin which is reduced in some specimens; this area is surrounded by dense punctures and pubescence; posterior margin of fifth sternum emarginate and impressed with sixth to form a shallow fovea. Legs reddish yellow. Male phallobase (Pl. II, Fig. 10) with basal lobe longer than ventral alae and parameres, bluntly pointed at apex with two raised lines uniting at upper third; basal lobe joined by membranes near tip to ventral alae which are more heavily sclerotized on ventral margins; parameres less than half the length of ventral alae with tufts of hair at apices reaching almost to ventral tips of ventral alae. Length, 1.9-2.3 mm; width, 1.4-1.6 mm.

Specimens examined: 36 males were collected from April 9 to July 28 and on October 1 and December 28. The one collected in December was found in a cotton boll.

Distribution records: Acadia, Allen, Ascension, Bossier, Cameron, East Baton Rouge, Jefferson, Madison (N.M.N.H.), Rapides, Sabine, St. Martin, Tangipahoa, Tensas, Webster, West Baton Rouge, and West Feliciana parishes.

Discussion: An examination of the type specimens revealed that _S. medionotans_ Casey, _S. subtropicus_ Casey, and _S. hortensis_ Wingo were synonyms of _S. creperus_ (Gordon, 1971, 1973). Mulsant described _S. creperus_ from New Orleans. The author has examined specimens from Texas, Louisiana, Mississippi and Florida. _S. creperus_ may be confused with _S. socer_, but in _S. creperus_ the fifth abdominal sternum of males is more deeply emarginate.

Scymnus (_Pullus_) _socer_ LeConte

Scymnus socer LeConte, 1852, p. 139.

Head reddish yellow. Pronotum reddish yellow with arcuate black spot at base which extends anteriorly one-half to four-fifths the length of the pronotum. Elytra black, narrowly edged with reddish yellow at apex. Prosternum reddish yellow, darker between coxae. Mesosternum and metasternum black. First 2 abdominal sterna black, remainder reddish yellow. First abdominal sternum of male with median glabrous area, usually a narrow triangle, outlined by dense punctures and pubescence; posterior margin of fifth sternum emarginate and impressed with sixth to form a shallow fovea. Legs reddish yellow. Male phallobase (Pl. II, Fig. 4) with basal lobe longer than parameres and shorter than ventral alae with ventral ridges rising to a point, scarcely curved dorsally, above the oval dorsal part; no pronounced trough below the point between dorsal and ventral surfaces; ventral alae attached at base of basal lobe, lightly sclerotized and expanded dorsally at the tips; parameres with tufts of hair at apices; ventral margins of basal piece straight. Length, 1.8-2.3 mm; width, 1.3-1.6 mm.

Specimens examined: 36 males were collected from April 28 to November 1. They were collected on Verbesina sp. infested with Dactynotus verbesinae Boudreaux, aphid-infested pyracantha, Solidago sp., crapemyrtle, cotton, red cedar, and arbor vitae.

Distribution records: Acadia, Ascension, Assumption, Calcasieu, East Baton Rouge, East Feliciana, Livingston, Natchitoches, Ouachita, Pointe Coupee, St. Mary, Tangipahoa, and West Feliciana parishes.

Discussion: This species was at first thought to be S. tenebrosus Mulsant based on the similarities of the genitalia and the fact that Wingo (1952) reported that the species in his study area was composed of both black specimens and specimens with pale areas on the pronotum and elytra, the genitalia of which were identical. However, S. tenebrosus and S. socer were collected together only once on arbor vitae in Baton Rouge. Sweep net collections in 11 other parishes yielded only S. socer. Further examination of the genitalia revealed that S. tenebrosus differs from S. socer as follows: the dorsal outline of the basal lobe is more rounded; apex of the ventral process is rounder and more dorsally curved; there is a pronounced trough below the point between the dorsal and ventral surfaces of the basal lobe; the ventral alae are broader at their apices; and the ventral margins of the basal piece curve outward at their apices. The two forms are different, although the genitalia are very similar.

This is the species referred to as S. kinzeli Casey (Chapin, 1971) according to information received from Gordon (1973).

Scymnus (Pullus) tenebrosus Mulsant

Scymnus tenebrosus Mulsant, 1850, p. 989.

Head and mouthparts reddish yellow in male, vertex darker; in female, head black, anterior margin and mouthparts reddish yellow. Pronotum and elytra black. Ventral surface of thorax black. Abdominal sterna black, last one reddish brown. First abdominal sternum of male with median triangular glabrous area surrounded by dense punctures and pubescence; fifth sternum emarginate and impressed with sixth to form a shallow fovea. Legs reddish brown; femora sometimes darker. Male phallobase (Pl. II, Fig. 3) with basal lobe longer than parameres and shorter than ventral alae with two ventral ridges rising to a point above rounded dorsal part; the point curves dorsally and is separated by a pronounced trough from dorsal part; ventral alae attached at base of basal lobe, heavily sclerotized in part and broadly expanded at tips; parameres with tufts of hair at apices; ventral margins of basal piece curved outward at apices. Length, 2.1-2.4 mm; width, 1.6-1.9 mm.

Specimens examined: 28 males. One specimen was collected May 10. The rest were collected June 11 in Baton Rouge on arbor vitae.

Distribution records: East Baton Rouge and West Feliciana parishes.

Discussion: The elytra are black although close scrutiny reveals a narrow reddish brown apex if the light and background are properly reflected. This species resembles S. compar but is larger and rounder. The male has a triangular median glabrous area on the first abdominal sternum and a deeper fovea in the fifth and sixth sterna. Scymnus tenebrosus is most closely related to S. socer, and this relationship is discussed under that species.

Scymnus (Pullus) puncticollis LeConte

Scymnus puncticollis LeConte, 1852, p. 139.

Head reddish yellow. Pronotum reddish yellow with median black spot at base which occupies less than half the length, rarely more and usually less, sometimes greatly reduced. Elytra black, narrowly edged with reddish yellow. Prosternum reddish yellow, black between coxae. Mesosternum and metasternum black. First abdominal sternum black, second black with pale lateral margins, remainder reddish yellow. First abdominal sternum of male convex at middle with median glabrous area surrounded by dense punctures and pubescence; fifth sternum deeply emarginate and impressed with sixth to form a fovea. Legs reddish yellow. Male phallobase (Pl. II, Fig. 6) with basal lobe a little shorter than ventral alae, longer than parameres and longer than length of ventral margins of basal piece; basal lobe with ventral process rising to a point above apex of dorsal part; ventral alae attached to basal two-thirds of basal lobe, rolled ventrally and expanded dorsally at tips; parameres with long tufts of hair at apices reaching to tips of ventral alae. Length, 2.1-2.6 mm; width, 1.4-1.8 mm.

Specimens examined: 11 males were collected in May. Seven were collected by beating trees along Vaughn Creek in West Feliciana Parish.

Distribution records: East Baton Rouge, East Feliciana, and West Feliciana parishes.

Discussion: S. puncticollis is closely related to S. natchezianus of Wingo (1952) and not that of Casey (1899) but differs in having the basal lobe longer, and the ventral alae are wider, rolled ventrally and expanded dorsally at the tips. This is the species referred to as S. lacustris LeConte (Chapin, 1971) according to information received from Gordon (1974a).

Scymnus (Pullus) natchezianus of Wingo, 1952, not Casey, 1899

Scymnus (Pullus) natchezianus Casey, (Wingo, 1952, p. 39, misidentification).

Head reddish yellow. Pronotum reddish yellow with rectangular black spot at base which extends anteriorly for half the length.

Elytra black, narrowly edged with reddish yellow at apex. Prosternum reddish yellow. Mesosternum and metasternum black. First 2 abdominal sterna black with pale lateral margins, remaining sterna reddish yellow. First abdominal sternum of male with median flat glabrous area surrounded by dense punctures and pubescence; fifth deeply emarginate and impressed with sixth to form a fovea. Legs reddish yellow. Male phallobase (Pl. II, Fig. 7) with basal lobe as long as ventral alae and longer than parameres, with ventral process which comes to a point above apex of rounded dorsal part; basal lobe nearly equal in length to ventral margins of basal piece; ventral alae relatively narrow, scarcely curved ventrally and attached to basal two-thirds of basal lobe; parameres with long tufts of hair apically which are somewhat longer than ventral alae. Length, 2.2 mm; width, 1.6 mm.

Specimens examined: One male was collected November 1 on Quercus michauxii Nutt. in Baton Rouge.

Discussion: Wingo (1952) identified specimens from Missouri and Kansas as S. natchezianus Casey (1899) realizing that their status might be changed when the type was dissected. The species which Wingo discussed is closely related to S. puncticollis, but the basal lobe is shorter, and the ventral alae are narrower and not rolled ventrally, nor are they expanded dorsally at their tips. The pronotal spot in the five known specimens varies from a rectangle occupying half the length of the pronotum to an arcuate black spot extending almost to the anterior margin. Robert D. Gordon will describe this species as new in his revision of the genus.

Scymnus (Pullus) uncus Wingo

Scymnus (Pullus) uncus Wingo, 1952, p. 38.

Head reddish yellow. Pronotum reddish yellow with rectangular black spot at base which extends anteriorly no more than one-third of length and is almost lacking in one specimen. Elytra black, narrowly edged with reddish yellow at apex. Prosternum reddish yellow. Mesosternum and metasternum black. First 2 abdominal sterna black, remainder reddish yellow. First abdominal sternum of male with large flat median glabrous area surrounded by dense punctures and pubescence; fifth broadly emarginate and impressed with sixth to form a fovea. Legs reddish yellow. Male phallobase (Pl. II, Fig. 5) with basal lobe a little shorter than ventral alae, longer than parameres, and with a pronounced ventrally produced hook at tip; ventral alae attached to basal two-thirds of basal lobe, broadly expanded and lightly sclerotized at tips; parameres with tufts of hair at apices. Length, 2.1-2.3 mm; width, 1.6-1.8 mm.

Specimens examined: 6 males. One specimen was collected April 27 on Salix nigra Marsh., one from a boll weevil sex attractant trap in May, three on arbor vitae in June, and one was swept from alligator weed on June 30.

Distribution records: East Baton Rouge and Tensas parishes.

Discussion: This species resembles S. puncticollis and S. natchezianus of Wingo (1952), not Casey (1899), but the glabrous area on the first abdominal sternum is larger and the fifth sternum is more broadly emarginate. The distinctive genitalia with the pronounced ventrally produced hook at the apex of the basal lobe will separate S. uncus from these species. Previously the species was known only from the type specimen collected in Monona County, Iowa.

Scymnus (Pullus) compar Casey

Scymnus (Pullus) compar Casey, 1899, p. 148.

Head dark brown basally, yellowish from anterior margin of frons distally in both sexes; a few males with head largely reddish yellow. Pronotum entirely black or black with anterior angles reddish brown. Elytra black; in some specimens apex appears narrowly reddish brown on close scrutiny. Prosternum black or with lateral margins pale. Mesosternum and metasternum black. Abdominal sterna black, last 2 or 3 sterna reddish brown. First abdominal sternum of male with large spade-shaped median glabrous area outlined by long pubescense; fifth slightly emarginate and impressed with sixth to form a shallow fovea. Legs reddish yellow or reddish brown; femora darker in some specimens. Male phallobase (Pl. II, Fig. 2) with basal lobe shorter than ventral alae and parameres with elevated ventral ridges rising to a point which is shorter than oval dorsal part and separated from it by a trough; ventral alae curved around basal lobe, connected to it by membranes, longer and more heavily sclerotized ventrally; parameres longer than basal lobe and shorter than ventral alae with terminal tufts of hair curved ventrally. Length, 1.8-1.9 mm; width, 1.3-1.4 mm.

Specimens examined: 16 were collected October 2 and 4 in Baton Rouge on red cedar.

Discussion: According to Gordon (1973), this is the species described as S. impunctus by Wingo (1952). The reddish brown apex of the elytra is not obvious and the elytra appear black. This species resembles S. tenebrosus but is smaller and more oval. The male differs in the spade-shaped median glabrous area on the first abdominal sternum and the shallower fovea of the fifth and sixth sterna.

Subgenus Nephus Mulsant

Nephus Mulsant, 1846, p. 237.

Prosternum without pair of carinae between coxae. Postcoxal lines on first abdominal sternum gradually curve posteriorly and are parallel to first abdominal suture, ending before lateral margin. Fifth abdominal sternum of male without secondary sexual characters.

Key to the species of the subgenus Nephus of Louisiana

1. Elytra pale brown or ferrugineous . . . . intrusus Horn
Elytra black, a round reddish yellow spot on each elytron behind middle. . . . . flavifrons Melsheimer

Scymnus (Nephus) flavifrons Melsheimer

Scymnus (Nephus) flavifrons Melsheimer, 1847, p. 181.

Head reddish yellow, vertex black in male; black with mouthparts reddish yellow in female. Pronotum black or black with anterior angles or lateral margins pale. Elytra black; each elytron with round reddish yellow spot behind middle, nearer suture than lateral margin. Ventral surface black, last abdominal sternum pale; sometimes with lateral margins of prosternum and median area of abdomen pale. Legs with femora black, tibiae and tarsi reddish yellow, sometimes entirely reddish yellow. Male phallobase figured on Pl. III, Fig. 1, 2. Length, 1.6-1.9 mm; width, 1.1-1.3 mm.

Specimens examined: 18 were collected in all months from April 14 to October 1 except August. Several were collected on cypress and oak.

Distribution records: Catahoula, East Baton Rouge, Livingston, Tensas, and West Feliciana parishes.

Discussion: Casey (1924) described S. ludovicianus from Alexandria, Louisiana, and said it differed from S. flavifrons in the much larger and somewhat more apical elytral spots. The type, a female, was examined, and the size of the elytral spots is within the range of individual variation of S. flavifrons.

Scymnus (Nephus) intrusus Horn

Scymnus intrusus Horn, 1895, p. 92.

Head, pronotum and elytra entirely pale brown or ferrugineous, pubescence white. Ventral surface pale brown or ferrugineous. Male phallobase figured on Pl. I, Fig. 15, 16. Length, 1.4-1.6 mm; width, 1.1 mm.

Specimens examined: 4 were collected in June in East Baton Rouge and Terrebonne parishes (N.M.N.H.).

Discussion: Garrett (1910) stated that this species was a predator of the sugarcane mealybug, Dysmicoccus boninsis (Kuwana), in south Louisiana. Specimens were collected again in 1932, but none were collected during this study.

Subgenus Diomus Mulsant

Diomus Mulsant, 1850, p. 951.

Postcoxal lines gradually curving to join posterior margin of first abdominal sternum. Prosternal carinae present or absent.

Key to the species of the subgenus Diomus of Louisiana

1. Elytra black, apex pale. 2
   Elytra black, marked with pale spots or fasciae. 3
2. Elytra black, apex narrowly yellow; pronotum reddish yellow . . . . .xanthaspis Mulsant
   Elytra black, apex with large median arcuate pale area occupying about one-fourth of length; pronotum reddish yellow with median black area of variable size. . . . . .terminatus Say
3. Each elytron with 2 large reddish yellow spots, variable in shape, sometimes connected. . . . . bigemmeus Horn ?
   Each elytron with anterior spot and posterior sinuate bar confluent with pale apical edge; pattern varying to two very small spots . . . . .amabilis LeConte

Scymnus (Diomus) amabilis LeConte

Scymnus amabilis LeConte, 1852, p. 135.

Head reddish yellow to reddish brown. Pronotum reddish yellow with median black spot of variable size at base, black with anterior angles pale, or entirely black. Elytra black with two spots and narrow apical edge reddish yellow, these markings variable in size or greatly reduced; anterior spot located in front of middle, closer to suture than lateral margin; posterior marking a sinuate bar or crescent extending to lateral margin and joining pale apical edge, or a small spot located closer to suture than lateral margin. Prosternum reddish yellow or black, pale laterally; prosternal carinae present. Mesosternum and metasternum black. Abdominal sterna black at base, pale at apex. Legs reddish yellow or with femora darker. Male phallobase figured on Pl. III, Fig. 3, 4. Length, 1.3-1.6 mm; width, 0.8-1.1 mm.

Specimens examined: 43 were collected April 9 and from June 5 to 10. The Baton Rouge specimens were beaten from cypress.

Distribution records: East Baton Rouge, and West Feliciana parishes.

Discussion: S. amabilis was described from New Orleans. This species was thought to be S. liebecki Horn until recent work by Gordon (1973) separated the two. Much variability exists in the size and shape of the spots in Louisiana specimens, and in one specimen the anterior spot is obsolete. The variety of S. quadritaeniatus which LeConte (1878) mentions from Opelousas is also a specimen of this species (Gordon, 1974c).

Scymnus (Diomus) bigemmeus Horn ?

Scymnus bigemmeus Horn, 1895, p. 88.

Head redish yellow. Pronotum reddish yellow with median black spot at base occupying about one-third of length. Elytra black; each elytron with 2 reddish yellow spots which are narrowly joined together, anterior spot smaller than posterior spot, located just before middle and closer to suture than to lateral margin; posterior spot large, almost equidistant from suture and lateral margin. Prosternum reddish yellow, posterior margin darker; prosternal carinae lacking. Mesosternum and metasternum black. Abdominal sterna reddish brown, darker at base and center. Legs reddish yellow. Length, 1.6 mm; width, 1.1 mm.

Specimens examined: One female was collected September 26 on camellia infested with Fiorinia theae Green in Pointe Coupee Parish, and one was collected in Cameron Parish on July 17.

Discussion: These females were tentatively identified as D. bigemmeus by Gordon (1974b) who explained that positive identification is not possible without males. The species was described from Florida.

Scymnus (Diomus) terminatus Say

Scymnus terminatus Say, 1835, p. 203.

Head yellow. Pronotum yellow with median black spot at base or black with lateral margins yellow. Elytra black with large median arcuate apical yellow area occupying about one-fourth the length. Prosternum yellow; prosternal carinae complete to anterior margin, converging slightly. Mesosternum and metasternum black. Abdomen with first 2 sterna black, pale laterally; remainder yellow. Male phallobase figured on Pl. III, Fig. 5. Legs yellow. Length, 1.6-1.8 mm; width, 1.1-1.3 mm.

Specimens examined: 122 were collected from April 1 to November 9.

Distribution records: Specimens were collected in 36 parishes, and the species is probably distributed throughout the state.

Discussion: This species was described from Louisiana. Scymnus partitus Casey (1899) was long considered a distinct species because the pronotum was reddish yellow with a broad black spot at the base. Specimens of this pronotal pattern are commonly collected with S. terminatus which has the pronotum black with lateral margins yellow. The male genitalia of the type of S. partitus were identical to the male genitalia of specimens of S. terminatus, and S. partitus is considered to be a synonym.

Scymnus (Diomus) xanthaspis Mulsant

Scymnus xanthaspis Mulsant, 1850, p. 952.

Head and pronotum reddish yellow. Elytra black narrowly edged with reddish yellow at apex. Prosternum reddish yellow; mesosternum and metasternum black. Abdominal sterna brown, paler at apex. Legs reddish yellow. Length, 1.4 mm; width, 0.9 mm.

Specimen examined: One female was collected May 20 in Tangipahoa Parish.

Genus Nephaspis Casey

Nephaspis Casey, 1899, p. 168.

Body elongate-oval, pubescent, hairs directed longitudinally. Head with front extended in front of eyes, clypeus deeply emarginate. Antennae with first 2 segments large, compressed, remainder small. Apical segments of maxillary palpi securiform. Pronotum as wide as base of elytra. Head in repose covering prosternum and anterior coxae, which are conical, widely separated at bases and contiguous at apices. Sternum convex, mesosternum truncate anteriorly. Elytral epipleura narrow, obsolete behind middle. Abdomen of 6 visible sterna; postcoxal lines incomplete, recurved toward base of abdomen, variable in extent. Tarsal claws slender and simple.

Two species have been described in the genus, N. gorhami Casey (1899) from Panama and N. amnicola Wingo (1952) from Iowa.

Nephaspis amnicola Wingo

Nephaspis amnicola Wingo, 1952, p. 44.

Head black basally, pale yellow brown distally. Mouthparts pale. Pronotum black, punctures faint. Elytra black, apical edge narrowly yellow; punctures coarse, more distinct than on pronotum. Ventral surface black, abdominal sterna 5 and 6 and usually narrow lateral margins of sterna 3 and 4 pale. Legs pale. Length, 1.3 mm; width, 0.8-0.9 mm.

Specimens examined: 5 females were collected September 26 on Viburnum sp. infested with whiteflies in Pointe Coupee Parish.

Discussion: This species is presently known only from the type series of three males. Although it is possible that the females collected in this study are not conspecific, it seems best to include them with this species until series containing both sexes become available. In color pattern they resemble N. brunnea Casey (1899) which he later (1905) designated as the female of N. gorhami.

Genus Cryptolaemus Mulsant

Cryptolaemus Mulsant, 1853, p. 268.

Body oval, convex, pubescent. Antennae ten-segmented. Terminal segments of maxillary palpi elongate securiform. Mandibles each with subapical tooth. Prosternum extended anteriorly to cover mouthparts and antennae in repose; prosternal carinae weak, parallel, extending less than halfway to anterior margin. Mesosternum weakly notched anteriorly. Abdomen with 6 visible sterna; postcoxal lines on first abdominal sternum complete. Tibial spurs absent. Tarsi three-segmented. Tarsal claws dimorphic, cleft in males, and with large basal subquadrate teeth in females.

One species of this genus was brought from Australia and introduced into California to control mealybugs.

Cryptolaemus montrouzieri Mulsant

Cryptolaemus montrouzieri Mulsant, 1853, p. 268.

Head and pronotum yellowish orange. Elytra lustrous black, each elytron with arcuate yellowish orange area at apex. Ventral surface with thoracic sterna black, prosternum and abdominal sterna yellowish orange; male with distinct fovea in sixth abdominal sternum. Legs black; male with prothoracic pair pale. Length, 3.6-4.6 mm; width, 2.6-3.3 mm.

Specimens examined: 7 from California.

Discussion: Garrett (1910) reported that C. montrouzieri was released in sugarcane plots in New Orleans to combat the sugarcane mealybug in 1908, but specimens were not recovered in 1909. He added that further introductions were planned. No specimens were collected during this study, but the species is included on the basis of the above report. This species has been reported from Florida (Muma, et al. 1961) and Indiana and Missouri (Wingo, 1952).

Tribe Hyperaspini Costa

Hyperaspini Costa, 1849, p. 9.

Dorsum glabrous. Scutellum relatively large, triangular. Eyes emarginate or entire. Elytral epipleura relatively narrow, foveate for reception of femoral tips or not. Abdomen with 6 visible sterna in female; male with very small visible seventh abdominal sternum. Anterior tibiae spinose, simple or with external plates. Tarsi cryptotetramerous. Basal lobe of male genitalia asymmetrical.

Leng (1920) included five genera in the tribe.

Key to the genera of the Hyperaspini of Louisiana

1. Each anterior tibia spinose at basal two-fifths with oblique double edge from spine to apex. . . . . Brachyacantha Chevrolat
   Each anterior tibia slender, not spinose at basal two-fifths . . . . .Hyperaspis Chevrolat

Genus Hyperaspis Chevrolat

Hyperaspis Chevrolat, 1837, p. 459.

Body elongate-oval to broadly oval; dorsal surface glabrous, punctate; abdominal sterna pubescent in a few species. Eyes finely faceted, not emarginate. Antennae eleven-segmented, short. Mandibles bifid at apices, toothed at base. Terminal segments of maxillary palpi securiform. Prosternum with 2 carinae which converge anteriorly. Elytral epipleura with distinct foveae for reception of femoral tips. Abdomen with 6 visible sterna in female, 7 in male, last one very small. Postcoxal lines on first abdominal sternum incomplete, recurved toward but not reaching base of abdomen. Tibiae slender, not spinose; each anterior tibia with external plate delimited by oblique suture at apex. Tarsi cryptotetramerous. Each tarsal claw with tooth at base, rudimentary in some species.

Dobzhansky reviewed the genus in 1941 and figured the color patterns and male genitalia of a number of species. Hyperaspis is the second largest genus in the United States.

Key to the species of Hyperaspis of Louisiana

1. Elytra with marginal vittae. 2
   Elytra without marginal vittae 3
2. Marginal vittae extending from humeri to apices, sinuate; elytra with pair of oval discal spots . . . . .undulata (Say)
   Marginal vittae extending from humeri to about middle; elytra with 2 pairs of spots, one discal, one apical . . . . . lateralis Mulsant
3. Each elytron with 3 pale spots, discal and marginal spots in front of middle and apical spot. . . . . pratensis LeConte
   Each elytron with less than 3 pale spots 4
4. Each elytron with two spots, separated or united 5
   Each elytron with one spot 7
5. Each elytron with large discal spot joined to large spot at apical margin, its inner outline concave. . . . . connectens (Thunberg)
   Each elytron with 2 separate spots, the larger on disc and the smaller at apex. 6
6. Basal lobe of male genitalia shorter than parameres, broad, truncate at apex, with rounded projection on right side of ventral surface, left side concave . . . . signata (Olivier)

Basal lobe of male genitalia as above, except with rounded projection on left side of ventral surface, right side concave . . . . .congressi Watson

7. Pale spot subapical, nearer lateral margin than suture . . . . .bigeminata (Randall)

   Pale spot discal 8

8. Pronotum with subquadrate yellow spots at lateral margins . . . . pinorum Casey

   Pronotum with lateral margins narrowly yellow in males, completely black in females 9

9. Basal lobe of male genitalia slightly shorter than parameres, long and narrow with straight sides, apex truncate. . . . .binotata (Say)

   Basal lobe of male genitalia shorter than parameres, broad, truncate at apex, with rounded projection on right side of ventral surface, left side concave . . . . signata (Olivier)

   Basal lobe of male genitalia as in H. signata, except with rounded projection on left side of ventral surface, right side concave . . . . .congressi Watson

Hyperaspis pratensis LeConte

Hyperaspis pratensis LeConte, 1852, p. 134.

Body roundly oval. Head black, mouthparts and antennae brown. Pronotum black, lateral margins yellow, convex internally. Elytra black; each elytron with three yellow spots, discal and marginal spots in transverse line in front of middle and apical spot (Pl. VII, Fig. 11). Length, 2.1 mm; width, 1.8 mm.

Specimens examined: One female was collected April 20 in East Baton Rouge Parish.

Hyperaspis lateralis Mulsant

Hyperaspis lateralis Mulsant, 1850, p. 657.

Head of male yellow, of female black. Pronotum of male black, anterior and lateral margins narrowly pale; of female, black. Elytra black with red markings; each elytron with marginal vitta along basal two-fifths of length, wider anteriorly, a discal spot and a smaller apical spot (Pl. VII, Fig. 12). Length, 2.6-3.8 mm; width, 2.1-2.9 mm.

Specimens examined: 40 were collected March 18 and from June 2 to 14.

Distribution records: Caddo, East Baton Rouge, and Tensas parishes.

Discussion: Dobzhansky (1941) reported that this species was common on scale-infested Monterey cypress along the California coast. Wingo (1952) listed a specimen from Juniperus virginiana infested with Pseudococcus juniperi. The majority of specimens were collected from cypress, but one was collected from arbor vitae. All of these plants belong to the family Cupressaceae.

Hyperaspis connectens (Thunberg)

Coccinella connectens Thunberg, 1808, p. 157.

Head of male yellowish orange; of female, black with anterior margin sinuately pale. Pronotum black, lateral margins broadly yellowish orange; anterior margin very narrowly pale in male. Elytra black, with markings yellowish orange; each elytron with large rounded or transverse discal spot and large spot at apical margin, its inner outline concave, the two connected, occasionally separate (Pl. VII, Fig. 13). Length, 2.3-2.9 mm; width, 1.8-2.3 mm.

Specimens examined: 102 were collected from April 1 to October 30, but none were collected in September. Most specimens were collected by sweeping.

Distribution records: Ascension, Avoyelles, Catahoula, East Baton Rouge, East Feliciana, Evangeline, Iberville, Lafayette, Livingston, Pointe Coupee, Rapides, St. Helena, St. James, St. John, St. Landry, St. Martin, Vermilion, West Baton Rouge, and West Feliciana parishes.

Hyperaspis binotata (Say)

Coccinella binotata Say, 1826, p. 302.

Head of male yellow, anterior and posterior margins banded with black; of female, black. Pronotum black with moderately wide pale lateral margins and narrow anterior margin pale in male; black in female. Elytra black, each elytron with round or slightly transverse reddish yellow spot slightly in front of middle (Pl. VII, Fig. 10). Male phallobase with basal lobe slightly shorter than parameres, long and narrow with straight sides, apex truncate (Fig. 123, Dobzhansky, 1941). Length, 2.1-2.9 mm; width, 1.6-2.3 mm.

Specimens examined: 23 were collected June 1 and 2 on Quercus sp. in Sabine Parish.

Discussion: This species may be separated from the two-spotted forms of H. signata and H. congressi by the shape of the basal lobe which is long and narrow with straight sides. The description of the male genitalia given by Watson (1960) does not agree with that of Dobzhansky (1941), but no explanation is given. Hyperaspis binotata, H. signata, and H. congressi belong to a group of species which are frequently misidentified because of the similarity of their color patterns.

Hyperaspis signata (Olivier)

Coccinella signata Olivier, 1808, p. 1047.

Head of male yellowish white, anterior and posterior margins banded with black. Pronotum of male black, lateral and anterior margins narrowly pale; sometimes only lateral margins pale. Head and pronotum of female black. Elytra black with one or two pairs of red spots, large pair on disc in front of middle and smaller pair at apex, which may be absent (P. VII, Fig. 6, 7). Male phallobase with basal lobe asymmetrical, much shorter than parameres, broad, truncate at apex, with rounded projection on right side of ventral surface, left side concave (Pl. IV, Fig. 14 and 15). Length, 2.6-3.9 m mm; width, 2.1-3.1 mm.

Specimens examined: 53 males were collected from March 28 to June 11. Most of the specimens were collected on magnolia or on spruce pine infested with Toumeyella sp.

Distribution records: East Baton Rouge, St. James, and Tensas parishes.

Discussion: Dobzhansky (1941) reported that the apical spots were reduced or lacking some specimens of H. signata. Specimens with two elytral spots were more numerous than those with four spots in the series collected in this study. Although minor individual variations in the shape of the basal lobe were noted, the male genitalia of the two forms were identical. Both forms resemble H. congressi, and the two-spotted form is similar to H. binotata. The shape of the basal lobe with the rounded projection on the right side of the ventral surface will separate H. signata from the other two species.

Hyperaspis congressi Watson

Hyperaspis congressi Watson, 1960, p. 211.

Head of male yellowish white, anterior and posterior margins banded with black. Pronotum of male black, lateral and anterior margins narrowly pale; sometimes only lateral margins pale. Head and pronotum of female black. Elytra black with one or two pairs of red spots, larger pair in front of middle and smaller pair at apex, which may be absent (Pl. VII, Fig. 8, 9). Male phallobase with basal lobe asymmetrical, much shorter than parameres, broad, truncate at apex, with rounded projection on left side of ventral surface, right side concave (Pl. IV, Fig. 16 and 17). Length, 2.8-3.6 mm; width, 2.1-2.8 mm.

Specimens examined: 21 males were collected from May 18 to June 10. The Baton Rouge specimens were collected on spruce pine infested with Toumeyella sp.

Distribution records: East Baton Rouge, Ouachita, and West Feliciana parishes.

Discussion: The two-spotted form of this species was described from Canada (Watson, 1960). Half of the males collected during this study had four elytral spots, but the male genitalia, while showing minor individual variations in the shape of the basal lobe, were otherwise identical. Hyperaspis congressi resembles H. signata. Both species have two color patterns, but the basal lobe of the male genitalia of congressi has the rounded projection on the left side of the ventral surface. Both species were collected on spruce pine infested with Toumeyella sp. The two-spotted form resembles H. binotata from which it is separated by the differences in the male genitalia.

Hyperaspis pinorum Casey

Hyperaspis pinorum Casey, 1924, p. 162.

Head yellowish orange in male, black in female. Pronotum black with subquadrate yellowish orange spots laterally; male with anterior margin also pale. Elytra black; each elytron with round or oval, red or orange discal spot, the center of which is caudad to middle of length (Pl. VII, Fig. 14). Length, 2.8-3.3 mm; width, 1.9-2.4 mm.

Specimens examined: 73 were collected from May 18 to August 2. Most of the specimens were collected on spruce pine infested with Toumeyella sp.

Distribution records: East Baton Rouge, Ouachita, and St. Tammany parishes.

Discussion: This species differs from H. binotata and the two-spotted forms of H. signata and H. congressi in the subquadrate pale spots on the pronotum.

Hyperaspis bigeminata (Randall)

Coccinella bigeminata Randall, 1838, p. 32.

Head yellowish orange in male with black band behind eyes, black in female. Pronotum black with subquadrate yellowish orange or pink spots laterally; male with anterior margin also pale. Elytra black with round subapical pink spot located nearer lateral margin than suture (Pl. VII, Fig. 15). Length, 2.8-3.1 mm; width, 2.3-2.4 mm.

Specimens examined: 3 were collected in May in boll weevil sex attractant traps.

Distribution records: Catahoula and Tensas parishes.

Hyperaspis undulata (Say)

Coccinella undulata Say, 1824, p. 92.

Head of male yellow; of female, black. Pronotum black, lateral margins broadly yellow; male with anterior margin yellow. Elytra black; each elytron with sinuate marginal vitta, widest at elytral apex, and oval discal spot (Pl. VII, Fig. 16). Length, 2.1-2.4 mm; width, 1.4-1.8 mm.

Specimens examined: 4 were collected from June 15 to September 18, but none were collected in August.

Distribution records: Cameron and Webster parishes.

Genus *Brachyacantha* Chevrolat

Brachiacantha Chevrolat, 1837, p. 458.

Body oval to broadly oval, glabrous. Antennae eleven-segmented. Eyes finely faceted and slightly emarginate. Terminal segments of maxillary palpi securiform. Epipleura foveate for reception of femoral tips. Abdomen with 6 visible sterna in female and 7 in male, last one very small. Postcoxal lines on first abdominal sternum incomplete, recurved toward but not attaining base. Abdomen of male with sterna 3 to 5 variously modified by cusps, depressions, and emarginations. Anterior tibiae spinose externally before middle, grooved from there to apices. Tarsi cryptotetramerous. Each tarsal claw with large internal tooth at base.

The genus was reviewed by Leng (1911), and a few species have been described since that time. The elytral pattern is intraspecifically variable.

Key to the species of *Brachyacantha* of Louisiana

1. Elytra pale, each elytron with black sutural stripe laterally expanded at 1/3 and 2/3, continued around apex, usually ending in marginal spot at apical third. . . . . *bollii* Crotch
   Elytra black with pale markings. 2
2. Elytra with basal spots lacking; each elytron with transverse antemedial band, narrow or wide, complete or divided, and subapical spot; third abdominal sternum of male bicuspid. .*dentipes* (Fabricius)
   Elytra with at least one basal spot on each side of suture 3
3. Spots 2 or 3 in number, rarely with 4 or 5 spots, in which case the humeral and discal spots are small and indistinct . . . . *quadripunctata* Melsheimer
   Spots 5 in number. 4
4. Size larger, 3 mm or more in length. . . . .*ursina* (Fabricius)
   Size small, less than 3 mm in length . . . .*felina* (Fabricius)

Brachyacantha dentipes (Fabricius)

Coccinella dentipes Fabricius, 1801, p. 381.

Head of male orange; of female black with median orange inverted triangular spot. Pronotum black with narrow orange apical margin and broad orange lateral margins, angulate toward disc. Elytra black, each elytron with discal and lateral orange spots in front of middle, sometimes joined to form transverse band which reaches margin but not suture, and subapical spot (Pl. VI, Fig. 6). Third abdominal sternum of male with 2 prominent cusps, fourth sternum shallowly and fifth deeply excavated at apical margins. Length, 5.1-5.4 mm; width, 3.6 mm.

Specimens examined: 3 were collected March 9 and April 7.

Distribution records: East Feliciana, Natchitoches, and Tangipahoa parishes.

Discussion: A number of varieties have been named as a result of the variable color pattern. Wingo (1952) included the forms B. socialis Casey, B. separata Leng and B. tau LeConte as synonyms.

Brachyacantha ursina (Fabricius)

Coccinella ursina Fabricius, 1787, p. 61.

Head yellow, anterior and posterior margins darker. Pronotum black with quadrate pale areas at lateral margins. Elytra black; each elytron with 5 yellow spots, one basal, one humeral, 2 in transverse line near middle, and one subapical (Pl. VI, Fig. 7). Length, 3.1 mm; width 2.4 mm.

Specimen examined: One female was collected October 30 in East Feliciana Parish.

Discussion: Wingo (1952) includes B. albifrons (Say) as a synonym.

Brachyacantha felina (Fabricius)

Coccinella felina Fabricius, 1775, p. 87.

Head yellow, anterior and posterior margins darker in female. Pronotum black; female with narrow anterior margin and quadrate areas at lateral margins yellow; male with anterior and lateral margins more broadly pale, black area shallowly bilobed at apex. Elytra black; each elytron with 5 yellow spots, one basal, one humeral, two in transverse line near middle and one subapical (Pl. VI, Fig. 8). Length, 2.1-2.8 mm; width, 1.4-1.9 mm.

Specimens examined: 31 were collected from May 17 to May 26 and on July 4 on pecan, Betula nigra L., and in boll weevil sex attractant traps.

Distribution records: Catahoula, Concordia, East Feliciana, Grant, Ouachita, Tensas, and West Feliciana parishes.

Discussion: This species is very similar to B. ursina but is smaller in size.

Brachyacantha bollii Crotch

Brachyacantha bollii Crotch, 1873, p. 379.

Head yellow, anterior margin, mouthparts and antennae darker. Pronotum black, with narrow yellow anterior margin and yellow quadrate areas at anterior angles narrowly extended posteriorly. Scutellum black. Elytra yellow; each elytron with black sutural stripe laterally expanded at one-third and two-thirds of length, continued around apex ending in marginal spot at apical third or extended to suture isolating an apical pale spot (Pl. VI, Fig. 9). Length, 2.8-2.9 mm; width, 2.1-2.3 mm.

Specimens examined: 2 were collected April 10 and June 15.

Distribution records: Natchitoches (Leng, 1911), Rapides, and Vernon parishes.

Discussion: The elytra vary from yellow to orange in color. Leng (1911) states that the elytral color pattern varies to black with five pale spots variously confluent or separate.

Brachyacantha quadripunctata Melsheimer

Brachiacantha 4-punctata Melsheimer, 1847, p. 178.

Leng (1911) reported that this species occurred in Louisiana, but it was not collected during this study. The description of the species is taken from Leng.

Body broadly rounded, glabrous. Male with head pale; pronotum pale with basal black area bilobed in middle, or all black except for narrow anterior border. Female with head black, front sometimes paler in V-shaped design; pronotum black, narrow margin about apical angles pale. Maculation of each elytron variable as follows: basal and subapical spots; humeral and basal spots not connected, subapical spot; humeral and basal spots connected or nearly connected, subapical spot; humeral, basal, marginal and subapical spots, sometimes minute discal spot. Length, 2.2-3.5 mm.

Discussion: Several varieties were named based on variations in the elytral pattern. Wingo (1952) includes B. basalis Melsheimer, B. confusa Mulsant, and B. flavifrons Mulsant as synonyms.

Tribe Scymnillini Casey

Scymnillini Casey, 1899, p. 112.

Body oval, small to minute in size, pubescent or apparently glabrous. Head strongly deflexed, deeply inserted in pronotum. Pronotum obviously narrower than elytra, deeply emarginate at apex, with narrowly reflexed lateral margins; base feebly lobed before scutellum. Eyes well-developed with narrow anterior emarginations.

Antennae very short, inserted very close to eyes, exposed at bases. Clypeus feebly sinuately-truncate. Apical segments of maxillary palpi securiform. Prosternum flat, devoid of carinae, widely separating anterior coxae. Abdomen with 5 visible sterna, fifth but little longer than two preceding. Epipleura narrow, flat, without fovea. Legs free; tibiae slender; tarsi well-developed; tarsal claws slender, apparently simple.

Sasaji (1968) did not include this tribe in his discussion of the phylogeny of the Coccinellidae. It appears to belong in the Scymninae, but its affinities with the other tribes of the subfamily have yet to be studied. Blackwelder (1945) included four genera in the tribe in the Western Hemisphere, one of which occurs in Louisiana.

Genus *Scymnillus* Horn

Scymnillus Horn, 1895, p. 110.

Size very small, oval. Body sparsely pubescent on head and pronotum; elytra glabrous with only a few hairs. Eyes narrowly emarginate. Antennae ten-segmented, very short, inserted close to eyes, exposed at bases. Clypeus short in front of antennae, truncate at apex. Labrum narrower than clypeus. Mandibles each with subapical tooth. Apical segments of maxillary palpi parallel-sided. Prosternum T-shaped; prosternal lobe broad, flat, without carinae, widely separating anterior coxae. Mesosternum truncate, broadly joined to metasternum. Epipleura narrow, flat, disappearing behind middle. Abdomen of 5 visible sterna, first longer than next 3, fifth a little longer than 2 preceding. Postcoxal lines incomplete, curving toward posterior margin of first abdominal sternum and running parallel to it to lateral margins. Tibiae without spurs. Tarsi cryptotetramerous. Each tarsal claw with small basal tooth.

Korschefsky (1931) included seven species in the genus.

Scymnillus aterrimus Horn

Scymnillus aterrimus Horn, 1895, p. 110.

Head black, mouthparts and antennae pale. Pronotum black. Head and pronotum sparsely punctate, each puncture bearing decumbent hair. Elytra black, glabrous, sparsely punctate, with only a few scattered hairs. Ventral surface black, lateral margins of prosternum, epipleura, and last abdominal sternum pale. Legs reddish yellow. Male phallobase figured on Pl. III, Fig. 6, 7. Length, 1.3-1.4 mm; width, 0.9 mm.

Specimens examined: 31 were collected from May 21 to June 11 and from October 2 to 4. Many were collected on cypress, arbor vitae, and red cedar.

Distribution records: Caddo, East Baton Rouge, and Rapides parishes.

Discussion: This species was described from northern California and Oregon and has been recorded from Florida (Muma, et al., 1961).

Subfamily Chilocorinae Sasaji

Chilocorinae Sasaji, 1968, p. 20.

Clypeus strongly expanded laterally. Antennae relatively short. Anterior margin of pronotum deeply trapezoidally concave and strongly descending laterally. Elytral base distinctly broader than pronotal base. Apical segments of maxillary palpi cylindrical, truncate apically. Metasternum with fovea for reception of middle femora. Elytral epipleura relatively broad and/or its inner carinae reaching elytral apex. Tibiae often angulate externally.

Sasaji (1968) included three tribes in the subfamily, one of which occurs in North America.

Tribe Chilocorini Costa

Chilocorini Costa, 1849, p. 9.

Form oval or round, moderately to strongly convex. Dorsal surface usually glabrous. Antennae with 7 to 10 segments. Clypeus strongly expanded laterally, concealing bases of antennae and subdividing eyes. Elytral epipleura wide, strongly slanted toward external margins. Prosternal lobe without carinae. Abdomen usually with 6 visible sterna in male, sixth very short; 5 in female. Tibiae occasionally modified, with or without terminal spurs. Tarsi cryptotetramerous. Tarsal claws simple or with basal teeth.

This tribe was reviewed by Chapin (1965a) who provided a key to the genera of the world as well as characterizations of the genera based as far as possible on the type species.

Key to the genera of the Chilocorini of Louisiana

1. Postcoxal lines complete to base of abdomen; elytral epipleura not foveate for reception of hind femora; tibiae with small spurs on last 2 pairs of legs, not toothed externally; antennae ten-segmented . . . . .Exochomus Redtenbacher
   Postcoxal lines not complete, either joining first abdominal suture or recurved halfway to base of abdomen 2
2. Postcoxal lines joining first abdominal suture; elytral epipleura

foveate for reception of hind femora; tibiae toothed at basal third and without spurs; antennae eight-segmented. . . . .Chilocorus Leach

Postcoxal lines recurved toward base of abdomen; elytral epipleura foveate for reception of hind femora; tibiae with small spurs on last two pairs of legs, not toothed externally; antennae ten-segmented. . . . . Axion Mulsant

Genus Axion Mulsant

Exochomus (Axion) Mulsant, 1850, p. 477.

Form rounded, stronlgy convex, upper surface glabrous. Antennae ten-segmented. Pronotum feebly punctate, but not pubescent at lateral margins. Elytra with lateral margins slightly reflexed; epipleura slightly foveate for reception of hind femora. Abdomen with 6 visible sterna in male, 5 in female; postcoxal lines on first abdominal sternum recurved toward, but not reaching, base of abdomen. Tibiae with small spurs on last two pairs of legs, not toothed externally. Each tarsal claw with quadrate tooth at basal half.

This is a North American genus. Korschefsky (1932) includes four species, two of which have been collected in Louisiana.

Key to the species of Axion of Louisiana

1. Elytra black; each elytron with round red subbasal spot . . . . plagiatum (Olivier)

Elytra black; each elytron with red basal elongate spot near humeral angle and narrow elongate spot along suture behind middle . . . . .tripustulatum (Degeer)

Axion tripustulatum (Degeer)

Coccinella 3-pustulata Degeer, 1775, p. 393.

Head black, pale anteriorly in male. Pronotum black, anterior angles narrowly pale, more noticeable in male. Elytra black, each elytron with red basal elongate spot near humeral angle and narrow elongate red spot along suture behind middle (Pl. V, Fig. 2). Ventral surface red, sternum, median areas of mesosternum and metasternum, and external margins of epipleura black. Legs black in female; black in male except for trochanters and spot of variable size on femora pale. Length, 5.9-7.3 mm; width, 5.4-6.3 mm.

Specimens examined: 11 were collected from March 3 to May 29 and on October 10.

Distribution records: Assumption, Avoyelles, East Baton Rouge, and Iberville parishes.

Axion plagiatum (Olivier)

Coccinella plagiata Olivier, 1808, p. 1044.

Head of male pale, vertex black; of female, black. Pronotum black, anterior angles narrowly pale. Elytra black, each elytron with round red subbasal spot located nearer lateral margin than suture (Pl. V, Fig. 1). Ventral surface black, sides of body and internal margins of epipleura pale. Legs black in female; male with extensive pale areas on prothoracic and mesothoracic legs; metathoracic legs darker. Length, 5.6-6.4 mm; width, 5.3-5.6 mm.

Specimens examined: 16 were collected June 2 on Quercus sp. in Caddo Parish.

Genus Chilocorus Leach

Chilocorus Leach, 1815, p. 116.

Form rounded, strongly convex, upper surface glabrous. Antennae eight-segmented. Pronotum pubescent toward lateral margins. Elytral margins not reflexed, finely beaded; epipleura excavated for reception of hind femora. Abdomen with 6 visible sterna in male, 5 in female; postcoxal lines join posterior margin of first abdominal sternum. Tibiae with triangular tooth on each at basal third and without spurs on all legs. Each tarsal claw with small quadrate tooth at base.

One species occurs in Louisiana.

Chilocorus stigma (Say)

Coccinella stigma Say, 1835, p. 202.

Head and pronotum black. Elytra black, each elytron with round red spot on disc in front of middle (Pl. IV, Fig. 7). Ventral surface with head and thorax black, abdomen red. Legs black. Length, 4.3-5.1 mm; width, 3.6-4.6 mm.

Specimens examined: 45 were collected from January 31 to November 1, but none were collected in March or July.

Distribution records: Assumption, Beauregard, Caddo, Calcasieu, DeSoto, East Baton Rouge, Natchitoches, Ouachita, Plaquemines, Rapides, Sabine, Tensas, West Baton Rouge, and West Feliciana parishes.

Discussion: The twicestabbed lady beetle, formerly known as Chilocorus bivulnerus Mulsant, is the most common species of this tribe in Louisiana. A number of specimens were collected on scale-infested magnolias. Cressman and Plank (1935) stated that it was a predator of the camphor scale, Pseudaonidia duplex (Cockerell). This species is sometimes confused with Olla abdominalis (Say) from which it is distinguished by the extension of the clypeus which subdivides the eyes and by the entirely black pronotum.

Genus Exochomus Redtenbacher

Exochomus Redtenbacher, 1843, p. 121.

Form broadly oval to almost circular. Antennae ten-segmented. Epipleura not foveate for reception of hind femora. Abdomen with 6 visible sterna in male, 5 in female; postcoxal lines of first abdominal sternum complete, or nearly so, to base of abdomen. Tibiae with small spurs on last two pairs of legs, not toothed externally. Tarsal claws each with subquadrate tooth at base.

One species is found in Louisiana.

Exochomus marginipennis (LeConte)

Coccinella marginipennis LeConte, 1824, p. 173.

Head black, pale anteriorly in male. Pronotum of male black with anterior angles or lateral margins widely pale; female with pronotum black, anterior angles only nubilously pale. Elytra with 2 color patterns: black with pale spot on each side of scutellum; sometimes with elongate pale spot on suture at middle which may be joined to the two at base; lateral margins of elytra sinuately pale for half or more of length (Pl. VI, Fig. 13, 14); or, elytra reddish orange, each elytron with subapical black spot of variable size and sometimes with black spot on disc above middle (Pl. VI, Fig. 15, 16). Length, 2.4-3.3 mm; width, 2.1-2.8 mm.

Specimens examined: 46 were collected from February 22 to August 20. Most of them were collected by beating oak or aphid-infested crapemyrtle.

Distribution records: Bossier, Caddo, East Baton Rouge, East Feliciana, Evangeline, Franklin, Grant, LaSalle, Nathchitoches, Ouachita, Rapides, Sabine, St. Helena, St. Landry, St. Tammany, Vernon, Washington, Webster and West Feliciana parishes.

Discussion: Exochomus guexi, one of the color forms of E. marginipennis, was described from Louisiana and named for Mr. J. A. Guex who collected specimens for LeConte. Other forms were described as E. childreni Mulsant, E. latiusculus Casey, and E. marginipennis deflectens Casey. Leng (1908) reported that all the varieties were represented in a series of specimens collected near St. Louis, Missouri, and that the pale form was more common in the southern states. In Louisiana, the black varieties were collected only in the Florida parishes while the red varieties were usually collected west of the Mississippi River. Both black and red varieties were collected in East Baton Rouge and West Feliciana parishes.

Subfamily Coccidulinae Sasaji

Coccidulinae Sasaji, 1968, p. 22.

Body weakly or moderately convex, pubescent. Head capsule normal with truncate apex and clypeus not expanded. Antennae eight- to eleven-segmented, laterally inserted. Compound eyes sometimes coarsely faceted. Mandibles bifid apically and toothed basally. Terminal segments of maxillary palpi strongly divergent and securiform. Elytral epipleura usually broad and entire without distinct foveae for reception of femoral tips. Mesosternum and metasternum narrowly articulate. Abdomen composed of 5 or 6 visible sterna. Tarsal formulae obviously tetramerous, cryptotetramerous, or true trimerous.

Three of the four tribes included in this subfamily occur in North America.

Key to the tribes of the Coccidulinae of Louisiana

1. Antennae eight-segmented; labrum distinctly broader than clypeus; tarsi cryptotetramerous . . . . .Noviini Ganglbauer
   Antennae eleven-segmented; labrum narrower than clypeus; tarsi true trimerous . . . . .Coccidulini Costa

Tribe Coccidulini Costa

Coccidulini Costa, 1849, p. 104.

Antennae eleven-segmented, rather long, usually longer than head capsule. Labrum narrower than clypeus. Compound eyes coarsely faceted. Base of mentum not very narrow. Prosternum T-shaped, surface nearly horizontal. Junction between mesosternum and metasternum moderate in width. Abdomen with 6 visible sterna. Tibiae simple, not angulate externally. Tarsi cryptotetramerous.

Three genera occur in the United States, one of which is found in Louisiana.

Genus *Lindorus* Casey

Lindorus Casey, 1899, p. 162.

Antennae eleven-segmented. Labrum narrower than clypeus. Epistoma deeply emarginate. Eyes coarsely faceted. Mandibles each with subapical tooth. Apical segments of maxillary palpi securiform. Prosternum T-shaped, prosternal carinae straight, complete to anterior margin. Each hypomeron with narrow deep groove extending from apex nearly to middle, parallel to lateral margin. Mesosternum shallowly emarginate at apex. Abdomen of 6 visible sterna, sixth very small. Postcoxal lines on first abdominal sternum complete. Tarsi cryptotetramerous. Tarsal claws slender, arcuate, bases slightly wider; male with first 2 pairs bifid.

The genus contains one species.

Lindorus lophanthae (Blaisdell)

Scymnus lophanthae Blaisdell, 1892, p. 51.

Elongate-oval, pubescent; pubescence consisting of black erect hairs and recumbent yellowish hairs. Head and pronotum reddish orange. Pronotum usually with dark cloud just before middle, variable in size and distinctness. Elytra brownish black with metallic lustre. Male genitalia figured on Pl. III, Fig. 8, 9. Length, 1.8-2.6 mm; width, 1.3-1.8 mm.

Specimens examined: 124 were collected from January 27 to December 30.

Distribution records: Allen, Beauregard, Caddo, Calcasieu, DeSoto, East Baton Rouge, East Feliciana, Franklin, Jefferson Davis, Natchitoches, Orleans, Ouachita, Pointe Coupee, Rapides, Sabine, St. Landry, Tangipahoa, Tensas, Vernon, West Baton Rouge, and West Feliciana parishes.

Discussion: This species was introduced into California from Australia. It has been collected on camellia and Ilex sp. infested with Fiorinia theae Green and on Melia azedarach L. infested with a bark scale. Lindorus lophanthae was recorded as a predator of Chrysomphalus dictyospermi (Morgan) by Cressman (1933).

Tribe Noviini Ganglbauer

Noviini Ganglbauer, 1899, p. 954.

Antennae eight-segmented and weakly clubbed. Eyes finely faceted. Labrum distinctly broader than clypeus. Mentum with very narrow base. Labial palpi two-segmented. Surface of prosternal lobe strongly raised. Junction between mesosternum and metasternum very narrow. Tibiae angulate externally. Tarsi true trimerous.

One genus occurs in Louisiana.

Genus Rodolia Mulsant

Rodolia Mulsant, 1850, p. 902.

Body oval to round, moderately convex, pubescent. Antennae eight-segmented, each with first segment broadly lobed, second globose, remainder smaller, club weak. Terminal segments of maxillary palpi broadly securiform. Each mandible with subapical tooth remote from apex. Abdomen with 6 visible sterna. Postcoxal lines on first abdominal sternum complete, rarely extending beyond middle of segment. Tibiae bluntly angulate externally. Tarsi three-segmented. Tarsal claws dimorphic, cleft in male, each with broad basal tooth in female.

One species has been introduced into the United States from Australia.

Rodolia cardinalis (Mulsant)

Vedalia cardinalis Mulsant, 1850, p. 906.

Head black, antennae and mouthparts red. Pronotum black with large rectangular area at each anterior angle, anterior and lateral margins red; or red with broad black bar at base. Elytra red with black marks; each elytron with spot partially enclosing humeral callus; a sutural stripe laterally expanded at basal third, continuing around apex as marginal stripe which joins outer of 2 postmedian spots; spots connected (Pl. VII, Fig. 17). Male with deep notch in sixth abdominal sternum. Length, 2.8-3.8 mm; width, 2.3-3.1 mm.

Specimens examined: 39 were collected from May 30 to June 10 and from October 9 to November 14 in East Baton Rouge Parish. A number of specimens were collected on magnolia or nandina infested with cottonycushion scale.

Discussion: This is the famous vedalia lady beetle which was introduced into California and later to Florida for the biological control of the cottonycushion scale. Louisiana entomologists first noticed the scale in 1912 (Tucker, 1914). It is not known when the lady beetle entered Louisiana, but specimens were collected in Baton Rouge in 1921.

Subfamily Coccinellinae Ganglbauer

Coccinellinae Ganglbauer, 1899, p. 954.

Body large to medium-sized, dorsal surface glabrous. Antennae long, eleven-segmented and inserted more or less dorsally. Each mandible with basal tooth, bifid apically or with several teeth arranged in row. Apical segments of maxillary palpi distinctly securiform. Mentum relatively narrowly articulated with submentum and strongly divergent apically. Prosternum T-shaped. Mesosternum relatively narrowly articulated with metasternum; mesepimeron nearly triangular and its posterior margin slightly bent. Abdomen always composed of 6 visible sterna. Femora elongate and not flattened. Tarsi always cryptotetramerous.

Sasaji (1968) places the tribes Coccinellini and Psylloborini in this subfamily.

Key to the tribes of the Coccinellinae of Louisiana

1. Anterior margin of clypeus with anterior projection on each side; mandibles always bifid apically . . . . .Coccinellini Weise
Anterior margin of clypeus truncate without anterior projection on each side; mandibles usually multidentate apically . . . . .Psylloborini Casey

Tribe Coccinellini Weise

Coccinellini Weise, 1885, p. 7.

Anterior margin of clypeus with anterior projection on each side, absent in some species of *Hippodamia*. Antennal insertion rather approximate to eyes. Anterior margin of pronotum usually deeply emarginate and with angulate anterior corners. Mandibles always bifid apically. Maxillary galea conical.

The tribe Coccinellini corresponds to the tribes Synonychini and Coccinellini of Korschefsky (1932) including the Hippodamiini and Anisostictini of Watson (1956). There are seventeen genera in America north of Mexico.

Key to the genera of the tribe Coccinellini of Louisiana

1. Body elongate, not markedly convex; femora extending well beyond sides of body when directed outwardly; head not deeply inserted, pronotum sinuate, but not covering eyes 2
Body rounded, convex, compact; femora not generally extending beyond sides of body; head deeply inserted, pronotum covering large part of eyes 4
2. Tarsal claws toothed or cleft 3
Tarsal claws simply widened basally, neither toothed nor cleft; pronotum with basal marginal bead; postcoxal lines on metasternum distinct; postcoxal lines on first abdominal sternum absent . . . .*Naemia* Mulsant
3. Each tarsal claw cleft at middle; pronotum without basal marginal bead; postcoxal lines on metasternum absent; postcoxal lines on first abdominal sternum present or absent . . .*Hippodamia* Chevrolat
Each tarsal claw with subrectangular basal tooth; base of pronotum with fine entire marginal bead; postcoxal lines on metasternum and first abdominal sternum absent . . . .*Coleomegilla* Timberlake
4. Each tarsal claw cleft near middle . . . .*Neomysia* Casey
Each tarsal claw with large tooth at base 5

5. Postcoxal lines arcuate, extending past middle of first abdominal sternum before recurving toward base of abdomen. . . .Adalia Mulsant
Postcoxal lines incomplete, curving laterally along first abdominal suture 6
6. Prosternum strongly convex at middle and prominent at middle of apex; mesosternum deeply sinuate at apex; pronotum with median black M-shaped design; elytra maculate . . . . .Anatis Mulsant
Prosternum and mesosternum not as above. 7
7. Pronotum always black with large quadrangular white spot in each anterior corner; elytral epipleura horizontal or only slightly concave; mesosternum truncate anteriorly; postcoxal plates on first abdominal sternum divided by oblique lines . . . Coccinella Linnaeus
Pronotal pattern and epipleura not as above. 8
8. Form elongate-oval, not strongly convex. 9
Form round, strongly convex. .10
9. Pronotal and elytral margins broadly reflexed; postcoxal plates divided by oblique lines which meet postcoxal lines; color pattern dimorphic. . . . . .Neoharmonia Crotch
Pronotal and elytral margins not broadly reflexed; postcoxal plates with oblique lines obsolete; elytra immaculate in Louisiana specimens; vittate elsewhere . . . . Mulsantina Weise
10. Elytra immaculate, yellowish orange or reddish orange. . . . . .Cycloneda Crotch
Elytra maculate, color pattern dimorphic, gray with black spots or black with 2 red spots. . . . . .Olla Casey

Genus Naemia Mulsant

Naemia Mulsant, 1850, p. 30.

Body elongate-oval, loosely formed, with femora extending beyond sides of body when extended outward. Pronotum with basal marginal bead. Prosternal lobe without carinae. Metasternum with postcoxal lines. First abdominal sternum without postcoxal lines. Tarsal claws simple.

The genus contains one species which Timberlake (1943) has divided into two subspecies, Naemia seriata seriata (Melsheimer) and Naemia seriata decepta (Blatchley). The former occurs in Louisiana.

Naemia seriata seriata (Melsheimer)

Coccinella seriata Melsheimer, 1847, p. 177.

Head black, mouthparts and antennae pale. Pronotum pale reddish yellow with 2 large black spots at base connected at median line and 2 smaller spots attached anterior-laterally, roughly forming a W. Elytra pale reddish yellow; each elytron with lateral row of 3 large black spots, usually connected, and 3 spots along suture (Pl. IV, Fig. 4). Length, 4.8-6.6 mm; width, 2.9-3.9 mm.

Specimens examined: 70 were collected from March 13 to October 16.

Distribution records: Acadia, Allen, Cameron, East Baton Rouge, East Feliciana, Iberia, Iberville, Jefferson, Lafourche, Livingston, Orleans, Plaquemines, St. Bernard, St. Landry, St. Tammany, Terrebonne, and Vermilion parishes.

Discussion: According to Leng (1903a) this species occurs in maritime regions. Glick (1939) collected a specimen by airplane over Tallulah.

Genus *Coleomegilla* Timberlake

Coleomegilla Timberlake, 1919b, p. 139.

Body elongate-oval, loosely formed with femora extending beyond sides of body when directed outward. Base of pronotum with fine entire marginal bead. Prosternal lobe without carinae. Metasternum and first abdominal sternum without postcoxal lines. Each tarsal claw with subquadrate basal tooth. Male with tarsi and antennae unmodified.

Coleomegilla was first used by Timberlake in 1919. In 1920 he credited the name to T. D. A. Cockerell who had given it to him as a replacement for *Megilla* Mulsant, 1850, which was preoccupied. Credit, however, must be given to the person who first published the name. Leng (1920) erroneously synonymized *Megilla* with *Ceratomegilla* Crotch.

The genus contains one species, *Coleomegilla maculata* (Degeer), which Timberlake (1943) divided into 12 subspecies and varieties, three of which occur in the United States. Timberlake also pointed out that *Megilla fuscilabris decepta* Blatchley was misidentified and is actually a southern race of *Naemia seriata* (Melsheimer).

The two subspecies which occur in Louisiana differ in size, color, pattern, and distribution, although their ranges overlap.

Key to the subspecies of *Coleomegilla maculata* of Louisiana

1. Pronotal spots large, triangular; elytral spots 2 and 3 united to form large oval mark, usually equidistant from suture and side margin; spot 5 nearly always united with its mate on suture; elytra red or pink. *lengi* Timberlake
   Pronotal spots reduced, oval or curvilinear; elytral spot 2 usually free, forming a smutting detached black spot near side margin; spots 5 separate; spots 4, 5, 6, reduced, usually subequal in size; elytra reddish or yellowish orange. . *fuscilabris* (Mulsant)

Coleomegilla maculata lengi Timberlake

Coleomegilla maculata lengi Timberlake, 1943, p. 9.

Head black with median red triangle. Pronotum red with large triangular black spot each side of middle at base, rarely confluent at middle. Elytra red with 2 common black spots, one scutellar and one at three-fourths; each elytron also with 4 spots arranged longitudinally, one on callus, one large median one, usually equidistant from suture and side margin, one at three-fourths and one subapical, not touching suture (Pl. VII, Fig. 1). Length, 4.9-6.4 mm; width, 2.8-3.9 mm.

Specimens examined: 138 were collected from February 13 to December 27.

Distribution records: This is a very common species on aphid-infested plants throughout the state and is the one referred to by various authors as C. fuscilabris or C. maculata. It was collected in 50 parishes but rarely occurs in the most southern ones.

Coleomegilla maculata fuscilabris (Mulsant)

Naemia fuscilabris Mulsant, 1866, p. 22.

Head black with median pale triangle. Pronotum and elytra reddish or yellowish orange. Pronotum with oval or curvilinear black spot each side of middle. Each elytron with 7 small black spots: spot ½ at scutellum united with its mate; spot 1 at humerus; spot 2 usually free, forming smutting detached black spot near side margin; spot 3 at middle, rectangular; spots 4, 5, and 6 reduced, usually subequal, but sometimes one may be half as large as others, spot 5 free from suture (Pl. VII, Fig. 2). Length, 4.1-5.8 mm; width, 2.4-3.3 mm.

Specimens examined: 60 were collected from March 13 to August 22.

Distribution records: Cameron, East Baton Rouge, Iberia, Iberville, Livingston, Natchitoches (Leng, 1903), Orleans (Mulsant, 1866), Plaquemines, St. John, St. Tammany, Tangipahoa, Terrebonne, and Vermilion parishes.

Discussion: Mulsant (1866) described C. m. fuscilabris from New Orleans. Leng (1903a) was apparently unaware of this description, for he redescribed the species as C. m. floridana from Florida and Vowells Mill, Louisiana. In this study the species was not collected north of Baton Rouge, although Glick (1939) collected a specimen by airplane over Tallulah. It is more common in the southern parishes of the state.

Genus Hippodamia Chevrolat

Hippodamia Chevrolat, 1837, p. 456.

Body elongate, loosely formed with femora extending beyond sides of body when directed outwardly. Male antennae not modified. Pronotum without basal marginal bead and with anterior margin nearly straight. Mesosternum without postcoxal lines. First abdominal sternum with or without postcoxal lines. Legs with two spurs on each middle and hind tibia; in a few species, the first segment of each anterior and middle male tarsus distinctly dilated; tarsal claws cleft at middle.

Brown and de Ruette (1962) reported that the name Hippodamia first appeared in the third edition of the Dejean catalog and was validated there like the names of the chrysomelid genera discussed by Barber and Bridwell (1940) and attributed by them to Chevrolat. Brown and de Ruette also stated that the abdominal postcoxal lines are always lacking in some species but are present and quite distinct in some but not all specimens of all other species in northern America that are placed in the genus.

Although both Casey (1899, 1908) and Leng (1903a) reviewed this genus, the first adquate classification was provided by Timberlake (1919a) who divided the genus into four groups of species. Chapin, reviewing the genus in 1946, accepted three of the four groups proposed by Timberlake, divided a fourth into two coordinate groups and added a sixth group for a newly described species. Brown and de Ruette (1962) added another species to the genus, bringing the total in America north of Mexico to seventeen, two of which occur in Louisiana.

Key to the species of Hippodamia of Louisiana

1. Each elytron with spots ½ to 6; spots small, black, and isolated; spots ½, 1, 2, and 3 often greatly reduced or lacking; elytra often immaculate . . . . convergens Guérin-Méneville
Each elytron with spot ½ an elongate dash either side of suture, sometimes joining spot 3 or absent altogether; spot 3 extended laterally, sometimes united with spot 2; spots 4 and 5 separate or united . . . . quindecimmaculata Mulsant

Hippodamia quindecimmaculata Mulsant

Hippodamia quindecim-maculata Mulsant, 1850, p. 20.

Head black at base, white anteriorly with black triangle near each antennal base. Pronotal disc black, enclosing two white divergent dashes, anterior and lateral margins white. Elytra reddish orange; each elytron with 6 or 7 large black spots; spot ½ an elongate dash either side of suture, sometimes joining spot 3 or absent; spot 3 extended laterally, sometimes united with spot 2; spots 4 and 5 separate or united; spots 1 and 6 present (Pl. IV, Fig. 6). Length, 6.6-7.3 mm; width, 4.1-4.6 mm.

Specimens examined: Eight specimens were collected May 16 and June 4 in West Feliciana Parish.

Discussion: Wingo (1952) examined a specimen in the Fall collection at the Museum of Comparative Zoology at Harvard University which was collected at Tallulah, Louisiana, on VII-19-30 by P. A. Glick. Chapin

(1946) stated that the species did not appear to be abundant in its range.

Hippodamia convergens Guérin-Méneville

Hippodamia convergens Guérin-Méneville, 1844, p. 321.

Head black at base, white anteriorly with black spot near each antennal base. Pronotal disc black enclosing two white divergent dashes, anterior and lateral margins white. Elytra reddish or yellowish orange; elytral pattern consisting of spots ½ to 6; spots small, black and isolated; spots ½, 1, 2, and 3 often greatly reduced or lacking; elytra often immaculate (Pl. IV, Fig. 5). Length, 5.3-7.1 mm; width, 3.3-4.4 mm.

Specimens examined: 131 were collected from February 12 to December 10.

Distribution records: The convergent lady beetle is very common on aphid-infested plants throughout the state. It was collected in 53 parishes.

Genus Neoharmonia Crotch

Neoharmonia Crotch, 1871, p. 2.

Form elongate-oval, not strongly convex. Lateral margins of elytra reflexed. Elytral punctures moderately strong. Elytral epipleura slightly concave, slanted toward lateral margins. Mesosternum convex and emarginate at apex. Postcoxal lines incomplete curving to run parallel to first abdominal suture. Postcoxal plates divided by oblique lines which meet postcoxal lines near first abdominal suture. Each tarsal claw with large basal tooth.

The genus was reviewed by Gordon (1974c). One subspecies composed of two color forms is found in Louisiana.

Neoharmonia venusta venusta (Melsheimer)

Coccinella venusta Melsheimer, 1847, p. 178.

Light form: head black, anterior margin and curved line by each eye pale. Pronotum and elytra reddish or yellowish marked with black. Pronotum with two apical median spots and two oblique basal vittae. Each elytron with two basal spots, middle row of two spots, median one prolonged obliquely forward along suture, and apical spot joining sutural vitta which ends at middle of length (Pl. V, Fig. 6).

Melanic form: head black, anterior margin yellow; pronotum black, anterior angles and sometimes narrow anterior and lateral margins reddish orange to yellowish white. Elytra black; each elytron with pale transverse fascia at middle extending to lateral margin; anterior margin of fascia deeply sinuate at middle forming two acute points; posterior margin slightly sinuate or occasionally each elytron with single triangular pale spot on disc (Pl. V, Fig. 5). Length, 4.6-6.6 mm; width, 3.4-5.1 mm.

Specimens examined: 44 were collected from February 22 to July 29 but none were collected in March. About half the specimens were collected in boll weevil sex attractant traps.

Distribution records: Assumption, Avoyelles, Catahoula, East Baton Rouge, Grant, Iberia, Iberville, Livingston, Point Coupee, Rapides, St. James, St. John, St. Tammany, Tensas, West Baton Rouge, and West Feliciana parishes.

Discussion: Mulsant (1850) described both color forms under the name of _Harmonia notulata_ and said that according to Sálle the species was found in Louisiana on young willows in the marshes. This species was erroneously referred to as _Coccinella affinis_ Randall by Summers (1874) and Townsend (1885).

Genus _Coccinella_ Linnaeus

Coccinella Linnaeus, 1758, p. 364.

Form broadly oval, convex. Head black with two pale spots on front or with pale band between eyes. Pronotum black with large quadrangular or triangular white spot in each anterior angle, sometimes joined together by pale band along anterior pronotal margin and rarely extended to basal pronotal angles. Elytra yellow, orange or red with variable black pattern, sometimes immaculate. Mesosternum truncate anteriorly. Elytral epipleura horizontal or only slightly concave. Postcoxal lines incomplete, curving to first abdominal suture and running parallel to it; postcoxal plates divided by distinct oblique lines which meet postcoxal lines very close to first abdominal suture. Each tarsal claw with tooth at base.

Early studies of the North American species of _Coccinella_ were conducted by Casey (1899, 1908) who recognized more than twice as many forms as separate species as did Leng (1903b). Dobzhansky (1931) stated that the genus is primarily holarctic in distribution. Using male genitalia as the principal character, he recognized 11 species and as many subspecies. Brown (1962) arranged the 18 forms considered to merit names as 12 species. The principal difference between his work and that of Dobzhansky was in the application of the subspecies concept.

Coccinella novemnotata Herbst

Coccinella 9-notata Herbst, 1793, p. 269.

Head with broad yellowish white band between eyes, black anteriorly and posteriorly. Pronotum with front margin and rectangular area at each front angle yellowish white. Elytra orange. Each elytron with 5 black spots; scutellar, confluent with its mate; small humeral spot; small spot near lateral margin in basal half; large median spot and large apical spot; spots variable in size and sometimes connected; elytral suture narrowly black (Pl. IV, Fig. 3). Male with pale spot on anterior face of each prothoracic coxa and pale stripe on ventral surface of each prothoracic femur. Length, 5.1-7.4 mm; width, 3.9-5.8 mm.

Specimens examined: 83 were collected from March 10 to October 23.

Distribution records: Dobzhansky (1931) recorded this species from Tallulah and Mound. It was collected in 34 parishes and is a common species on many crops north of Baton Rouge. One specimen was collected in Cameron Parish in extreme southwest Louisiana.

Genus Cycloneda Crotch

Cycloneda Crotch, 1873, p. 371.

Body rounded, very convex. Elytra immaculate. Mesosternum truncate anteriorly or at most slightly sinuate at middle. Postcoxal lines incomplete, curving toward lateral margins parallel to first abdominal suture; oblique lines of postcoxal plates obsolete. Epipleura more or less concave and slanted toward external elytral margins. Each tarsal claw with tooth at base.

"The center of the specific diversity of Cycloneda lies in Central and South America, where it, and some related genera, replace Coccinella completely," reported Dobzhansky (1931).

Timberlake (1943) stated that he had conducted reciprocal crosses between the three North American species of Cycloneda, C. sanguinea (Linnaeus), C. munda (Say), and C. polita Casey, which showed that they were interspecifically sterile. Two species occur in Louisiana, and they have been confused in the literature.

Key to the species of Cycloneda of Louisiana

1. Pronotal pattern with isolated white spots; male with metathoracic tibiae black; male genitalia with basal lobe knobbed at tip; mesothoracic and metathoracic tibiae black in female . . . . .sanguinea (Linnaeus)
   Pronotal pattern lacking isolated white spots; male with metathoracic tibiae pale; male genitalia with basal lobe pointed at apex; female with all tibiae pale . . . . munda (Say)

Cycloneda sanguinea (Linnaeus)

Coccinella sanguinea Linnaeus, 1763, p. 10.

Head white in male, vertex black; white with median black triangle in female. Pronotum with large median black basal area surrounding 2 lateral white spots; anterior margin, lateral margins and hind angles white; male with apical median white prong; occasionally white spots are connected posteriorly with white lateral margins. Scutellum black. Elytra yellowish orange to reddish orange (Pl. VII, Fig. 3). Male with prothoracic and mesothoracic legs pale, external margins sometimes black; metathoracic legs mostly black. Legs of female with femora black, tips pale; prothoracic tibiae pale; mesothoracic and metathoracic tibiae black; tarsi pale. Male genitalia with basal lobe knobbed at tip. Length, 4.1-6.1 mm; width, 3.3-5.1 mm.

Specimens examined: 148 were collected from January 20 to November 21.

Distribution records: This species was collected in 48 parishes and is the more common of the two species of Cycloneda, especially in the southern part of the state. Wingo (1952) collected a single specimen in Missouri during the course of his study.

Cycloneda munda (Say)

Coccinella munda Say, 1835, p. 202.

Head white in male, vertex black; white with median black triangle in female. Pronotum black at base, anterior margin, lateral margins and hind angles white; white anterior margin extended posteriorly as 2 long curved lateral branches and narrow median triangular branch; lateral branches sometimes reaching base, isolating a black spot; occasionally white pronotal spots almost enclosed by black. Scutellum black. Elytra vary from yellowish orange to reddish orange (Pl. VII, Fig. 4). Legs of male pale; metathoracic femora black except at tips; female with femora black except at tips, tibiae and tarsi pale. Male genitalia with basal lobe pointed at apex. Length, 3.6-5.4 mm; width, 2.9-4.4 mm.

Specimens examined: 100 were collected from March 10 to November 21. One specimen was collected February 13 from ground trash near a soybean field.

Distribution records: This species was collected in 45 parishes and is more abundant in the northern part of the state. Wingo (1952) reported that it is common in all the states of the upper Mississippi basin.

Discussion: Cycloneda munda differs from C. sanguinea in the following respects: in both sexes the pronotal pattern lacks isolated white spots and possesses an apical median white prong; the male has the metathoracic tibiae pale; the basal lobe of the male genitalia is pointed at the apex; and the female has all the tibiae pale.

Genus Olla Casey

Olla Casey, 1899, p. 93.

Rounded, convex. Elytral epipleura concave and strongly slanted toward external margins. Prosternal lobe with 2 carinae, variably distinct, parallel or convergent. Mesosternum emarginate at apex. Postcoxal lines incomplete, curving toward lateral margins parallel to first abdominal suture; oblique lines of postcoxal plates frequently distinct but incomplete. Each tarsal claw with large basal tooth.

The genus is represented in the United States by a single species which is composed of two color forms.

Olla abdominalis (Say)

Coccinella abdominalis Say, 1824, p. 95.

Head gray with two black spots on vertex. Pronotum gray with seven black spots; two diagonal spots at center, three along basal line, separate or fused to form M-shaped figure; each lateral margin with spot behind middle. Elytra gray; each elytron with transverse series of four small black spots at base, median series of three spots and posterior spot near lateral margin. Occasionally each elytron with 1 or 2 of inner spots of basal row lacking; or, large black spot on disc behind middle, transversely sinuate anteriorly, oval posteriorly, with two isolated black spots near lateral margin, one at anterior and one at posterior margin of larger spot, posterior spot sometimes lacking (Pl. VI, Fig. 1, 2).

Melanic form: head white with two black spots on vertex, sometimes spotted with black on front. Pronotum with large median black spot; anterior margin, medial spur and lateral margins white; occasionally black area bears lateral spurs which rarely become separate spots. Elytra black; each elytron with yellow or red spot before middle (Pl. VI, Fig. 3). Length, 4.1-6.1 mm; width, 3.4-5.1 mm.

Specimens examined: 197 were collected from January 17 to November 21. The species is common on aphid-infested plants.

Distribution records: The species was collected in 52 parishes and is generally distributed throughout the state.

Discussion: Blaisdell (1931) illustrated the variation in the elytral pattern of the pale form of O. abdominalis collected in one locality in California. The form named O. arizonae Casey fits very well at one end of his series. The black forms named O. plagiata Casey and O. sobrina Casey differ from each other principally in the color pattern of the pronotum. Specimens can be arranged in a series to illustrate the range of variation.

Both the pale and the melanic form of this species have been collected on the same plants in most areas of the state, but the black form has been collected more often. The male genitalia of the two forms are identical.

Genus Adalia Mulsant

Adalia Mulsant, 1850, p. 49.

Form elongate-oval, not strongly convex. Postcoxal lines almost complete, extending past middle of first abdominal sternum before recurving to end just before coxal cavities. Each tarsal claw with large basal tooth.

There are two species in this genus which is northern in distribution.

Adalia bipunctata (Linnaeus)

Coccinella 2-punctata Linnaeus, 1758, p. 364.

Head black with white spot adjacent to each eye. Pronotum yellowish white with median M-shaped mark varying to median area black; lateral margins broadly pale. Elytra red; each elytron with round black spot at the middle (Pl. VII, Fig. 5). Length, 4.8-5.1 mm; width, 3.8-4.1 mm.

Specimens examined: Three specimens were collected June 10 in Caddo Parish.

Discussion: This is a northern species reported by Wingo (1952) from all the states of the upper Mississippi basin. The author has examined specimens from Arkansas and Starkville, Mississippi.

Genus Mulsantina Weise

Mulsantina Weise, 1906, p. 34.

Form elongate-oval, moderately convex. Prosternal lobe without carinae. Mesosternum convex and slightly sinuate medially in front. Postcoxal lines incomplete, curving toward lateral margins parallel to first abdominal suture; oblique lines of postcoxal plates absent. Each tarsal claw with large basal tooth.

Weise (1906) proposed Mulsantina as a new name for Cleis Mulsant, 1850, which was preoccupied. Pseudocleis Casey, 1908, is a synonym.

Two species occur in the United States, one of which is described as new.

Key to the species of Mulsantina of Louisiana

1. Pronotum with median black M-shaped mark and black spot attached at

middle of each lateral leg; elytra reddish orange, immaculate in Louisiana, maculate in other areas . . . . picta (Randall)
Pronotum with slightly curved black stripe each side of middle and black spot in each lateral area, sometimes joined to median stripes basally; elytra yellowish orange, immaculate . . . luteodorsa Chapin

Mulsantina picta (Randall)

Coccinella picta Randall, 1838, p. 51.

Head black with 3 pale spots, sometimes joined at middle. Pronotum yellowish white with median black M-shaped mark and black spot attached at middle of each lateral leg; pattern sometimes reduced to its component spots. Elytra reddish orange, immaculate (Pl. VI, Fig. 4); in some areas of United States, each elytron with dark vitta running from callus to near apex connected with transverse bars before middle and at apex, variable in extent of pigmentation. Male genitalia (Pl. III, Fig. 12, 13) with basal lobe slightly longer than parameres, curved dorsally at apical third with apex between tips of parameres; apex of basal lobe bluntly rounded; each paramere with apex blunt with long hairs which extend halfway down medial margin; sipho with apical fourth abruptly narrower. Length, 4.3-5.3 mm; width, 3.1-4.1 mm.

Specimens examined: 52 were collected from February 25 to August 21, but none were collected in July. Most of them were collected on aphid-infested slash pine or spruce pine infested with Toumeyella sp.

Distribution records: East Baton Rouge, Livingston, Pointe Coupee, St. James, Tensas, and West Feliciana parishes.

Discussion: The genitalia of the maculate and immaculate forms of this species are identical, but the latter is the only one which has been collected in Louisiana. Specimens have also been examined from Starkville, Mississippi, and College Station, Texas.

Since the early coleopterists named so many color forms, it is rather surprising that this one did not receive more attention. Randall (1838) and Crotch (1873) mention it as one of the extremes of variation in the color pattern of M. picta. Weise (1895) named it M. impictipennis, but the name was apparently unknown to American taxonomists until the publication of Korschefsky's catalog in 1932. Casey (1899) did not mention it at all. Leng (1903b) reported that the elytra of male M. picta were immaculate while those of the female, the apparently more abundant sex, were more or less variegated with black. Johnson (1910), apparently unaware of Weise's work, renamed the form M. blanchardi in honor of the man who called his attention to the fact that this was not a sex difference, but one which occurred throughout the range.

Gaines (1933) collected a series of this form at College Station, Texas, and reported that Dr. E. A. Chapin knew of no species like it. He listed it as M. concolor Crotch although he realized the specimens did not fit the description in all respects.

Wingo (1952) did not mention examining specimens with immaculate elytra. He considered M. hudsonica Casey to be a synonym of M. picta (Randall). The distribution of this species was listed as generally northern, although occasional specimens were collected in the southern states of the upper Mississippi basin.

Mulsantina luteodorsa Chapin

Mulsantina luteodorsa Chapin, 1973, p. 1073.

Head white in male, vertex black; in female, head white, black anteriorly and posteriorly, labrum dark; antennae white. Pronotum white with slightly curved black stripe each side of middle, extending from base almost to apex, stripes sometimes joined basally; an isolated black spot in each lateral pale area, sometimes joined to median stripe basally. Scutellum pale. Elytra yellowish orange, immaculate (Pl. VI, Fig. 5). Males with first 2 pairs of legs pale, metathoracic legs with femora black, paler at bases and apices; females with femora black, pale apically; tibiae and tarsi pale, tibiae sometimes streaked with black externally. Male genitalia (Pl. III, Fig. 14, 15) with basal lobe as long as parameres, curved dorsally near tip, its apex between tips of parameres; apex of basal lobe bluntly pointed; each paramere curved inward at tip which is pointed and more heavily sclerotized with short hairs subapically; sipho abruptly narrowed at tip. Length, 3.8-4.6 mm; width, 3.1-3.4 mm.

Specimens examined: 13 were collected April 11 and 24 and June 2.

Distribution records: Caddo, East Baton Rouge, and Sabine parishes.

Discussion: The Baton Rouge specimens were collected on basket oak.

The genitalia of this species is very similar to M. picta (Randall), but is distinctly shorter. The basal lobe is shaped differently when viewed ventrally and the tip is narrower. The tips of the parameres are narrowly pointed and the hairs are shorter. The narrow portion at the tip of the sipho is considerably shorter than it is in M. picta.

The pronotal pattern of M. luteodorsa differs from that found in other members of the genus, but the male genitalia are of the same type.

Blackwelder (1945) lists 7 specific names in the genus from North and Central America and the West Indies. The genitalia of this species are different from those of M. picta (Randall), M. cyathigera (Gorham), and M. mirifica (Mulsant). Timberlake (1943) reported that M. lynx (Mulsant) has genitalia identical to M. mirifica and agreed with Crotch that it was only a variety of the latter. A female of M. concolor (Crotch) was examined and did not agree with females of this species. No specimens of M. labyrinthica (Sicard), 1929, or M. picta nubilata (Casey), 1924, but the pronotal and elytral patterns are different according to the original descriptions.

Genus *Anatis* Mulsant

Anatis Mulsant, 1846, p. 133.

Broadly oval, convex. Size large, more than 5 mm in length. Antennae long, extending beyond middle of prosternum. Prosternum broad between coxae; strongly convex at middle and prominent at middle of apex. Mesosternum deeply sinuate at apex. Postcoxal lines incomplete, ending at posterior margin of first abdominal sternum. Each tarsal claw with large basal tooth.

McKenzie (1936) reported that two species and two subspecies occur in North America. One species is found in Louisiana.

Anatis quindecimpunctata (Olivier)

Coccinella quindecimpunctata Olivier, 1808, p. 1027.

Head black with yellow spot next to each eye. Pronotum yellow with median black M-shaped mark extending almost to anterior border and black spot at each lateral margin just behind middle. Elytra yellow or reddish brown; each elytron with 8 black spots in 3 rows; basal row with 2 spots, middle and posterior rows each with 3 spots (Pl. V, Fig. 4). Length, 7.8-7.9 mm; width, 6.6-6.8 mm.

Specimens examined: 2 were collected April 20 and May 22.

Distribution records: Jackson and Tensas parishes.

Discussion: Wingo (1952) stated that this was the most common species of the genus in the southern half of the upper Mississippi basin.

Genus *Neomysia* Casey

Neomysia Casey, 1899, p. 98.

Body broadly oval, convex, minutely punctate. Size large, more than 5 mm in length. Antennae long, extending beyond middle of prosternum. Prosternum narrow between coxae and feebly convex along median line. Mesosternum slightly sinuate. Postcoxal lines incomplete, ending at first abdominal suture. Tarsal claws cleft near middle.

Casey (1899) proposed the name *Neomysia* because he believed the American species differed from the European genotype of *Mysia* Mulsant, 1846. By 1905 he was inclined to think that American and European species were congeneric, but pointed out that *Neomysia* would have to replace *Mysia* which was a preoccupied name. Timberlake (1943) believed the North American species were so similar to *N. oblongoguttata* that they should be considered as races. He did not, however, examine all the species described in the genus.

Neomysia oblongoguttata pullata (Say)

Coccinella pullata Say, 1826, p. 301.

Head pale with median triangular black spot. Pronotum yellowish white with median trapezoidal black or dark brown area; anterior and lateral margins pale with black spot, usually isolated, in each lateral margin. Elytra brownish yellow, sometimes with faint vittae laterally and posteriorly (Pl. V, Fig. 3). Male with slight notch in sixth abdominal sternum. Length, 6.6-7.1 mm; width, 4.9-5.6 mm.

Specimens examined: 4 were collected from April 24 to July 19, but none were collected in June.

Distribution records: East Baton Rouge and West Feliciana parishes.

Discussion: Many specimens of this species were collected on catalpa nectaries and persimmon flowers in Arkansas by L. D. Newsom.

Tribe Psylloborini Casey

Psylloborini Casey, 1899, p. 100.

Anterior margin of clypeus truncate without anterior projection on each side. Antennal insertion more frontally situated. Anterior margin of pronotum weakly sinuate and with rounded corners. Mandibles often multidentate apically. Maxillary galea quadrate.

One genus occurs in the United States.

Genus _Psyllobora_ Chevrolat

Psyllobora Chevrolat, 1837, p. 458.

Body broadly oval, moderately convex, small; color pale with darker spots; integument thin. Pronotum diaphanous at edges and broadly reflexed. Each mandible with basal tooth and several teeth at apex. Prosternal lobe without carinae. Mesosternum truncate. Postcoxal lines on first abdominal sternum incomplete, joining posterior margin. Tibial spurs absent. Each tarsal claw with large quadrate tooth at base.

Timberlake (1943) provided a key to some of the North American species based on differences in the male genitalia. He also stated that many of the species described by Casey were unjustly merged as varieties of _P. vigintimaculata_ in the Leng catalog (1920).

The three Louisiana species can be separated on the basis of their color patterns. Many specimens were collected on crapemyrtle and elm infested with powdery mildew.

Key to the species of Psyllobora of Louisiana

1. Each elytron with 9 spots of uniform color, some of which may be confluent 2
   Each elytron with 2 basal spots, large reniform discal spot, and usually, spot near suture at 1/3 and subapical spot; pronotum with 5 brown spots, lateral ones usually fused . . . . . .renifera Casey
2. Pronotum with 5 black spots, antescutellar spot small, sometimes obsolete; sipho of male genitalia with very long tenuous portion at apex . . . . vigintimaculata (Say)
   Pronotum with 5 pale brown spots, sometimes so faint that disc appears nebulously darker; sipho with short slender point at apical end . . . . parvinotata Casey

Psyllobora vigintimaculata (Say)

Coccinella 20-maculata Say, 1824, p. 96.

Head pale, vertex black. Pronotum and elytra yellowish white. Pronotum with 5 median black spots, 2 at middle and 3 at base, antescutellar spot small, sometimes obsolete. Each elytron with 9 black spots: 2 subbasal; 2 near the suture at one-third and two-thirds; 3 near lateral margin at one-third, two-thirds and subapical; and 2 discal, latter often connected and sometimes joining others together (Pl. VI, Fig. 10). Male genitalia with sipho elongate, tapering from just before middle into very long tenuous portion. Length, 1.9-2.4 mm; width, 1.4-1.8 mm.

Specimens examined: 66 were collected from February 25 to October 2, but none were collected in September.

Distribution records: Acadia, Assumption, Avoyelles, Caddo, Calcasieu, Catahoula, DeSoto, East Baton Rouge, East Feliciana, Franklin, Grant, Jefferson Davis, Lafayette, LaSalle, Madison, Natchitoches, Ouachita, Pointe Coupee, Rapides, Red River, Sabine, St. Landry, Tangipahoa, Tensas, and West Baton Rouge parishes.

Psyllobora parvinotata Casey

Psyllobora parvinotata Casey, 1899, p. 101.

Head pale, vertex black. Pronotum and elytra yellowish white or gray. Pronotum with 5 median pale brown spots, 2 at middle, 3 at base, antescutellar spot often absent, sometimes all spots indistinct. Each elytron with 9 black spots: 2 subbasal; 2 near suture at one-third and two-thirds; 3 near lateral margin at one-third, two-thirds and subapical, two discal, latter sometimes connected (Pl. VI, Fig. 11).

Sipho of male genitalia tapering to short slender point at apical end. Length, 2.1-2.6 mm; width, 1.6-1.9 mm.

Specimens examined: 29 were collected February 25 and from May 15 to June 14.

Distribution records: Acadia, Calcasieu, Jefferson Davis, and Lafayette parishes.

Discussion: Casey (1899) stated that P. parvinotata is very similar to P. vigintimaculata in elytral maculation, but differs in the absence of the antescutellar spot on the pronotum. The spot may be present or absent in both species. In P. vigintimaculata the pronotal spots are black, and the apical end of the sipho is very long and thread-like. In P. parvinotata the pronotal spots are pale brown, sometimes so faint that the disc appears nebulously darker, and the apical end of the sipho ends in a short fine point.

Psyllobora renifera Casey

Psyllobora renifer Casey, 1899, p. 102.

Head pale, vertex dark brown. Pronotum and elytra yellowish white or gray. Pronotum with 5 median brown spots, lateral spots usually fused. Each elytron with 2 basal spots, sometimes united, spot near the suture at one-third, large bilobed discal spot extending from basal third to apical fifth, and subapical spot, sometimes obsolete; some or all spots may be joined to extensive discal spot (Pl. VI, Fig. 12). Length, 1.9-2.6 mm; width, 1.6-1.9 mm.

Specimens examined: 80 were collected from May 10 to June 8 and from October 2 to 4.

Distribution records: Bossier, Calcasieu, Catahoula, DeSoto, East Baton Rouge, Iberville, Ouachita, St. Landry, Tensas, and West Baton Rouge parishes.

Discussion: This species resembles P. parvinotata in pronotal pattern and male genitalia, but in P. renifera the pronotal spots are always present and darker.

Subfamily Epilachninae Ganglbauer

Epilachninae Ganglbauer, 1899, p. 947.

Medium-sized to large beetles, more than 6 mm long, strongly convex. Dorsal surface always pubescent. Antennae eleven-segmented, inserted more between than before eyes. Each mandible multidenticulate at tip and without basal tooth. Apical segments of maxillary palpi securiform. Mentum very broadly articulated with submentum and convergent apically. Mesepimeron quadrate, its posterior margin distinctly angulate. Abdomen with 6 visible sterna. Tarsi always cryptotetramerous.

One genus of this subfamily occurs in the Western Hemisphere.

Genus Epilachna Chevrolat

Epilachna Chevrolat, 1837, p. 460.

Oval, convex. Dorsal surface pubescent. Elytral punctures both coarse and fine. Epipleura flat. Postcoxal lines on first abdominal sternum usually complete to base of abdomen. Abdomen of 6 visible sterna, sixth loosely hinged, sometimes retracted or deflected dorsally; in female, sixth may or may not be divided longitudinally. Each tarsal claw bifid, with or without basal tooth.

The genus is a tropical one. Dieke (1947) reviewed the species of Asia, Europe, and Australia.

Key to the species of Epilachna of Louisiana

1. Yellowish orange; pronotum usually with 4 black spots; each elytron with 7 large round black spots; sixth abdominal sternum of female divided longitudinally . . . . .borealis (Fabricius)
   Pale yellowish brown; pronotum immaculate; each elytron with 8 small black spots; sixth abdominal sternum of female not divided longitudinally . . . . .varivestis Mulsant

Epilachna borealis (Fabricius)

Coccinella borealis Fabricius, 1775, p. 82.

Body yellowish orange. Head, mouthparts and antennae pale. Pronotum pale with apical and basal black spot on median line, basal spot larger, sometimes composed of two spots, a black spot near each lateral margin; spots sometimes reduced or absent. Scutellum dark. Elytra pale; each elytron with 7 black spots, 3 subbasal, 3 median, and an apical one larger than the rest; inner subbasal and median spots united or not at suture (Pl. IV, Fig. 1). Sixth abdominal sternum notched at apex in male, divided longitudinally in female. Length, 7.6-8.5 mm; width, 6.3-7.3 mm.

Specimens examined: 82 were collected from January 13 to December 23, but none were collected in February and March.

Distribution records: Acadia, Ascension, Calcasieu, Concordia, East Baton Rouge, Iberia, Iberville, LaFourche, Ouachita, Rapides, St. Helena, St. James, and West Felician parishes.

Discussion: This is the common squash beetle which feeds on various cucurbitaceous plants.

Epilachna varivestis Mulsant

Epilachna varivestis Mulsant, 1850, p. 815.

Body pale yellowish brown. Head and pronotum pale. Scutellum dark. Elytra pale, each elytron with 8 small black spots in 3 transverse rows, 3 subbasal, 3 median and 2 apical, inner spot more anterior (Pl. IV, Fig. 2). Sixth abdominal sternum notched at apex in male, entire in female. Length, 6.8-7.6 mm; width, 5.4-6.1 mm.

Specimens examined: 73 were collected from May 16 to September 7.

Distribution records: East Baton Rouge, Madison, Tensas, Washington (Eddy, 1940), and West Baton Rouge parishes.

Discussion: Chapin (1936) pointed out the reasons why the scientific name of this species was changed from E. corrupta to E. varivestis. The Mexican bean beetle appeared in Louisiana for the first time at Bogalusa in 1938, according to Eddy (1940). Beans infested with this species have been examined in several locations since then.

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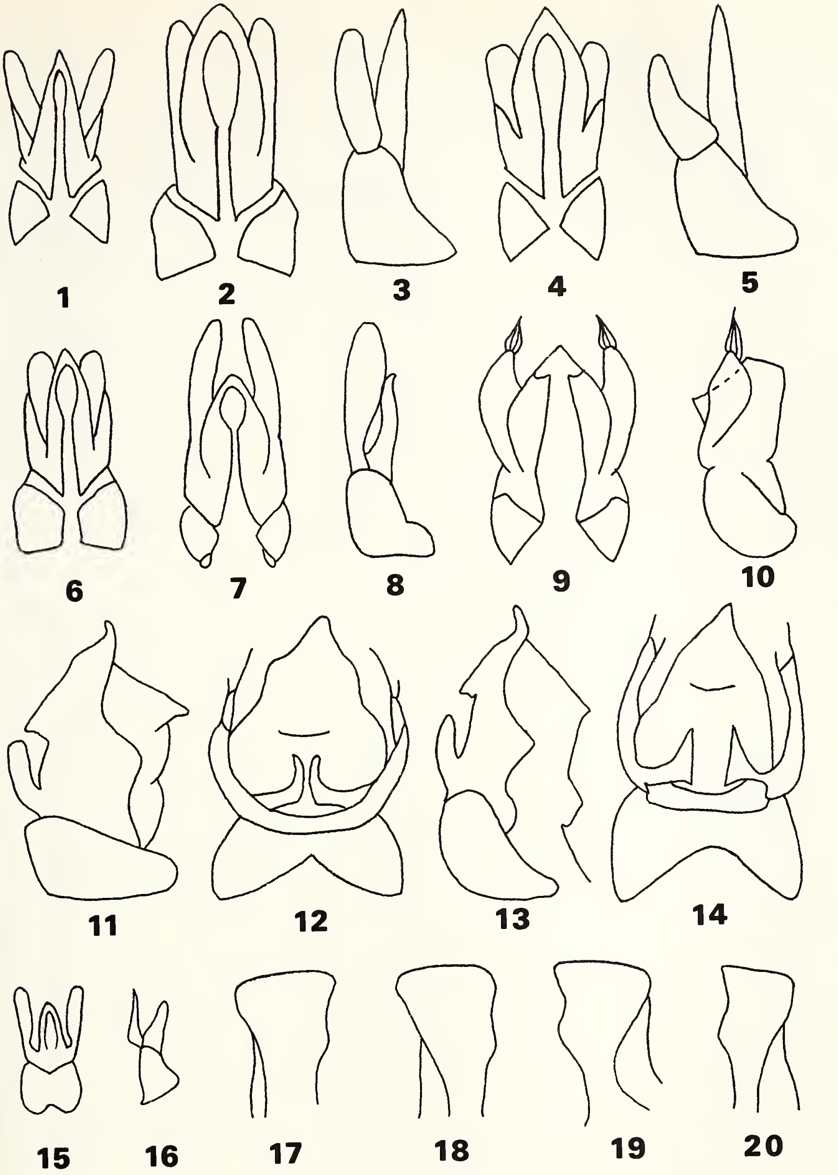


Plate I. Fig. 1-8.--Ventral and lateral views of male phallobases without hair tufts on parameres: 1, *Scymnus indianensis*; 2, 3, *S. apicanus*; 4, 5, *S. paracanus*; 6, *S. circumspectus*; 7, 8, *S. nebulosus*. Fig. 9, 10.--*S. securus*: 9, phallobase, ventral view; 10, same, lateral view. Fig. 11, 12.--*S. louisianae*: 11, phallobase, lateral view without parameres; 12, same, dorsal view with parameres. Fig. 13, 14.--*S. fraternus*: 13, phallobase, lateral view without parameres; 14, same, dorsal view with parameres. Fig. 15, 16.--*S. intrusus*: 15, phallobase, ventral view; 16, same, lateral view. Fig. 17-20.--Basal lobes of phallobases: 17, *Hyperaspis signata*, four-spotted form; 18, *H. signata*, two-spotted form; 19, *H. congressi*, four-spotted form; 20, *H. congressi*, two-spotted form. (All figures are 64X.)

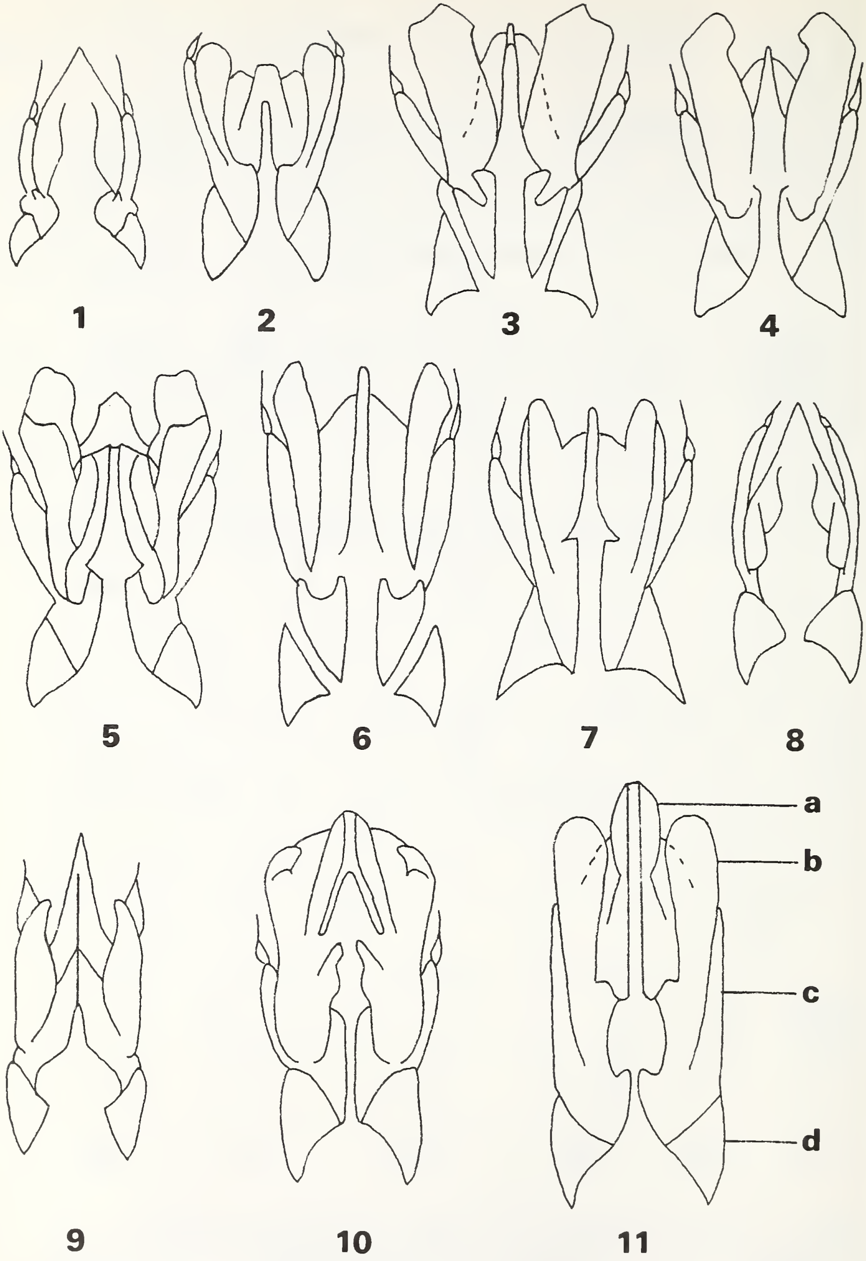


Plate II. Fig. 1-11.--Ventral views of male phallobases: 1, *Scymnus loewii*; 2, *S. compar*; 3, *S. tenebrosus*; 4, *S. socer*; 5, *S. uncus*; 6, *S. puncticollis*; 7, *S. natchezianus* of Wingo; 8, *S. rubricaudus*; 9, *S. cervicalis*; 10, *S. creperus*; 11, *S. brullei*: a, basal lobe; b, ventral ala; c, paramere; d, basal piece. (All figures are 68X.)

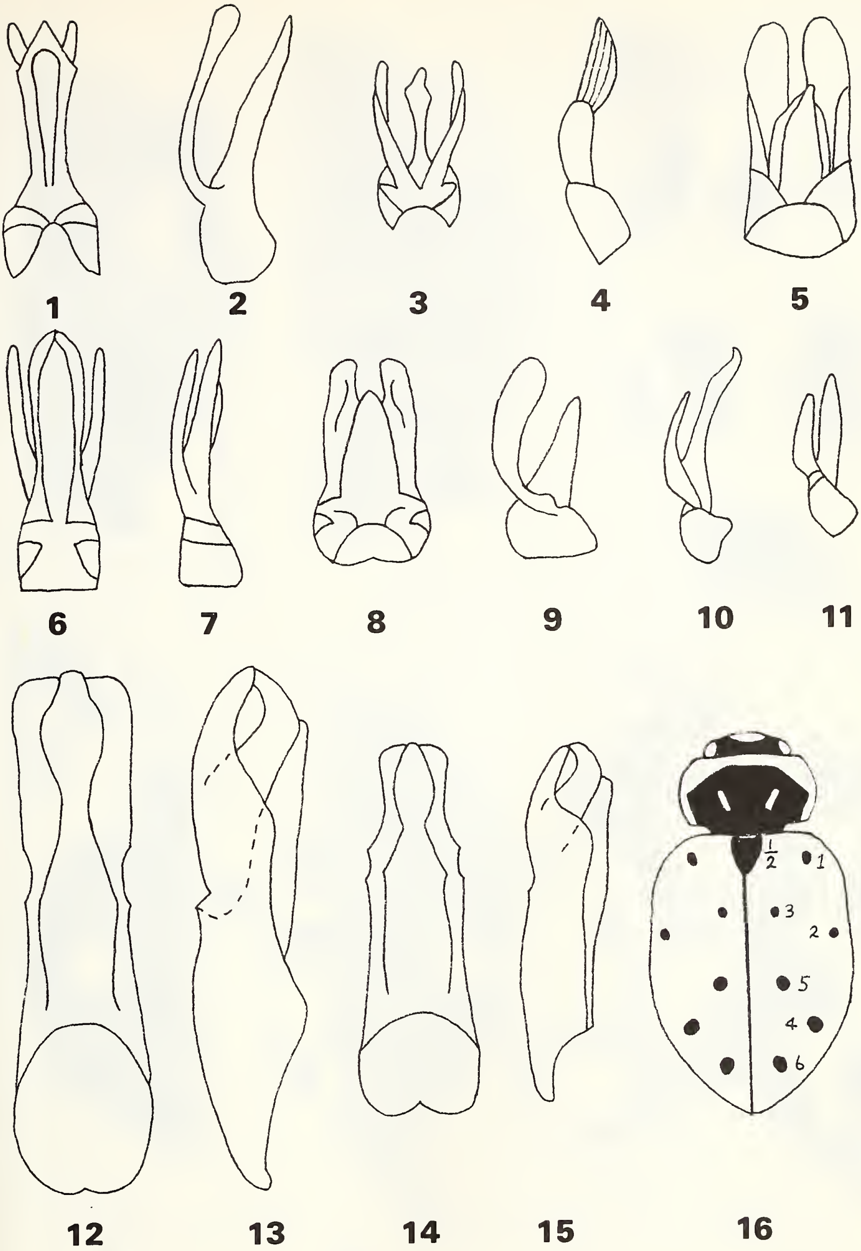


Plate III. Fig. 1-15.--Ventral and lateral views of male phallobases, Fig. 3, 5-7, 10-15 without hair tufts on parameres: 1, 2, Scymnus flavifrons; 3, 4, S. amabilis; 5, S. terminatus; 6, 7, Scymnillus aterrimus; 8, 9, Lindorus lophanthae; 10, Stethorus punctum; 11, S. utilis; 12, 13, Mulsantina picta; 14, 15, M. luteodorsa. Fig. 16.--Hippodamia convergens, dorsal view illustrating numbering of elytral spots. (Figures 1 to 11 are 68X; figures 12 to 15 are 53X.)

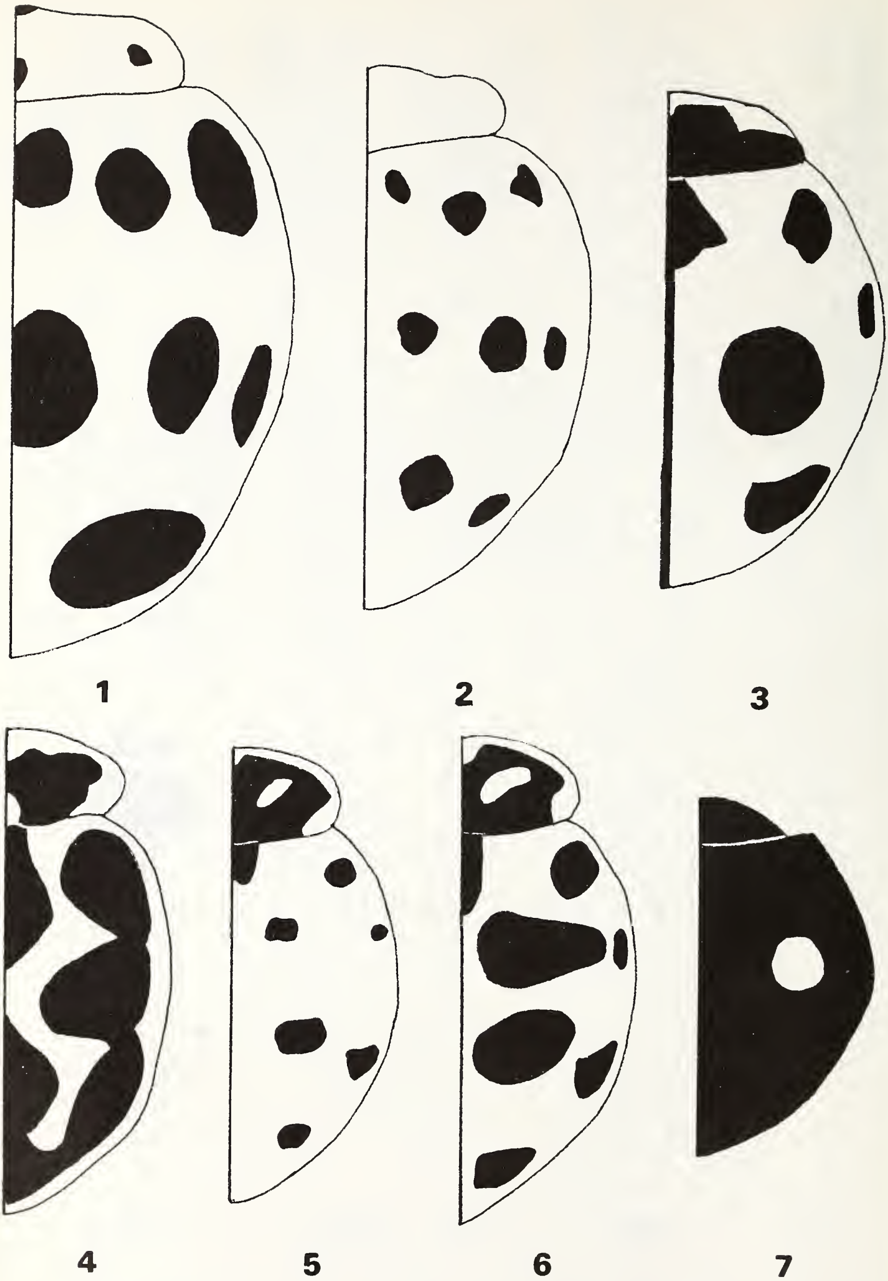


Plate IV. Dorsal views of right halves of lady beetles. 1, Epilachna borealis; 2, E. varivestis; 3, Coccinella novemnotata; 4, Naemia seriata seriata; 5, Hippodamia convergens; 6, H. quindecimmaculata; 7, Chilocorus stigma. (All figures are 9X.)

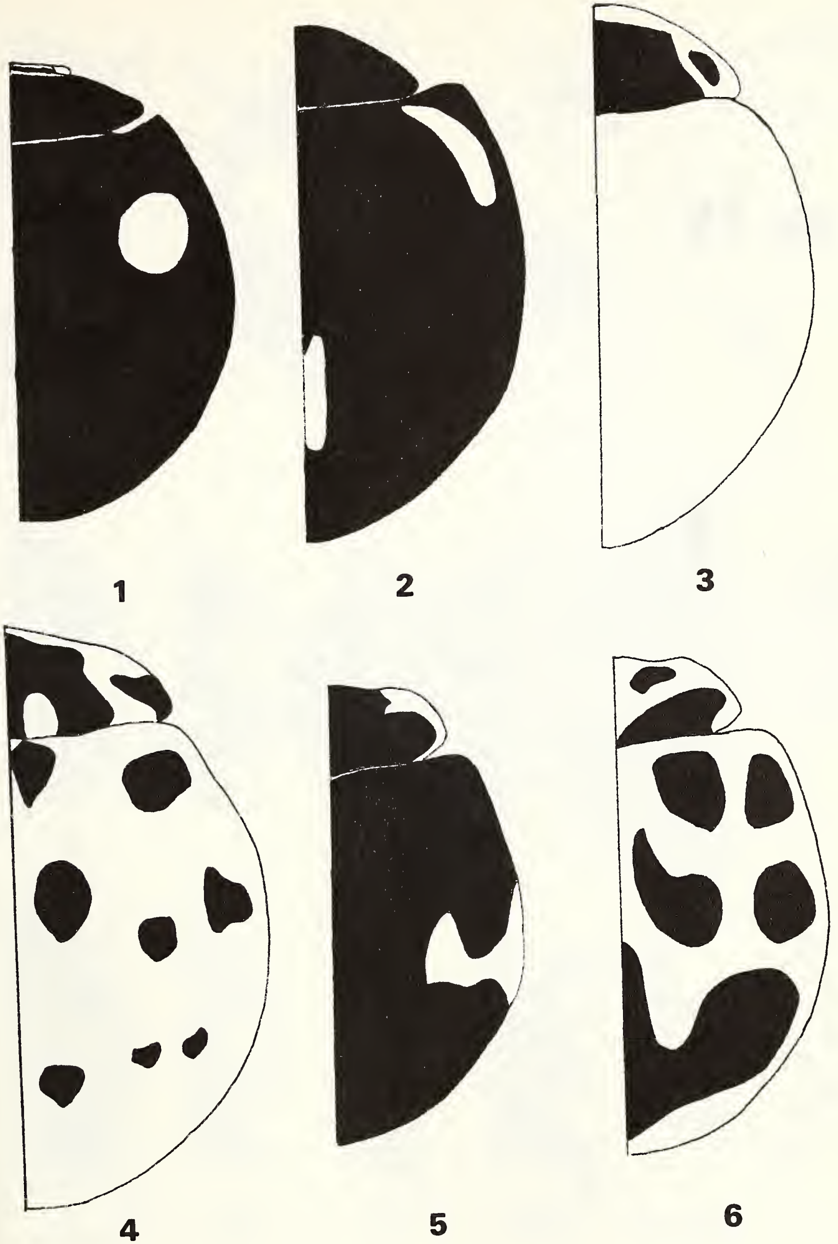


Plate V. Dorsal views of right halves of lady beetles. 1, *Axion plagiatum*, ♂; 2, *A. tripustulatum*; 3, *Neomysia oblongoguttata pullata*; 4, *Anatis quindecimpunctata*; 5, 6, *Neoharmonia venusta venusta*. (All figures are 9X.)

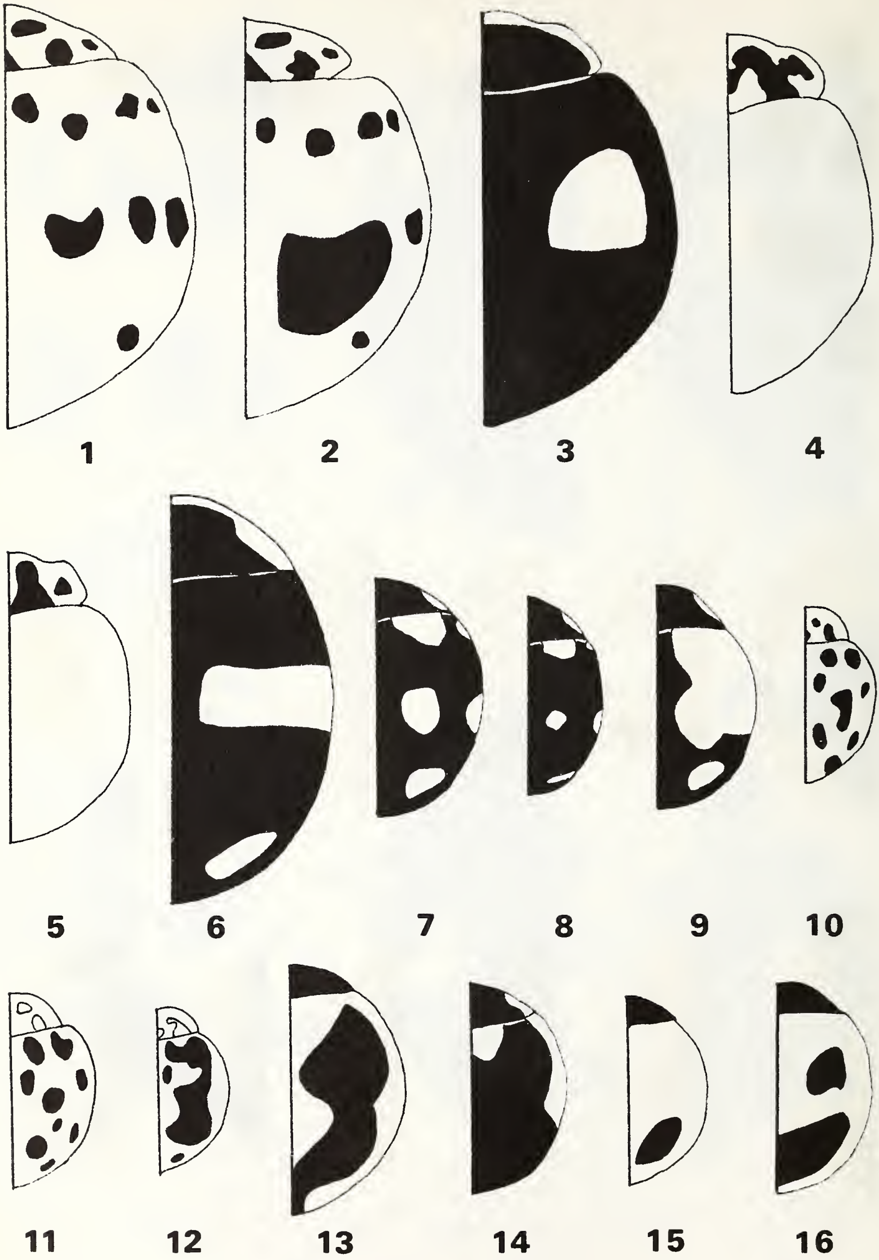


Plate VI. Dorsal views of right halves of lady beetles. 1-3, *Olla abdominalis*; 4, *Mulsantina picta*; 5, *M. luteodorsa*; 6, *Brachyacantha dentipes*; 7, *B. ursina*; 8, *B. felina*, ♀; 9, *B. bollii*; 10, *Psyllobora vigintimaculata*; 11, *P. parvinotata*; 12, *P. renifera*; 13-16, *Exochomus marginipennis*; 13, 15, 16, ♀♀; 14, ♂. (All figures are 9X.)

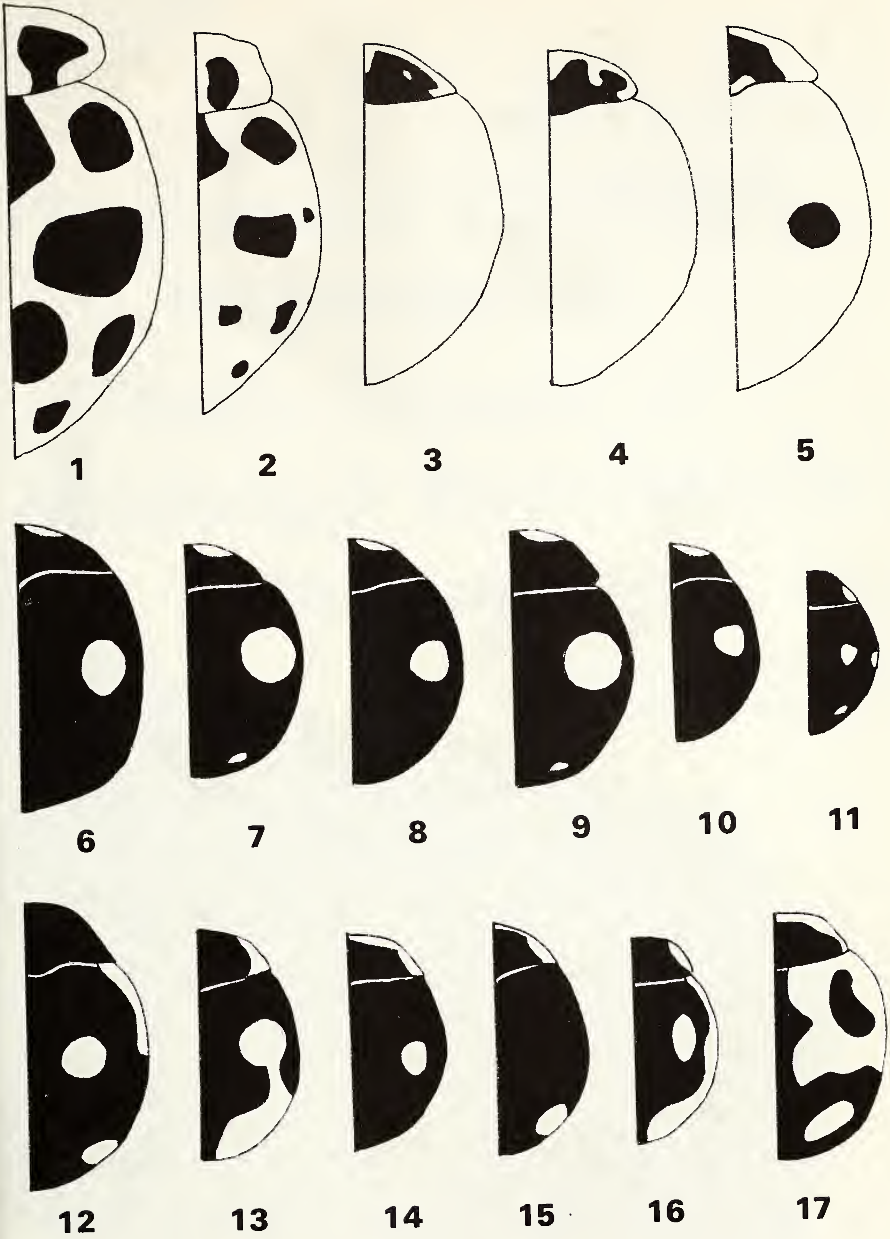
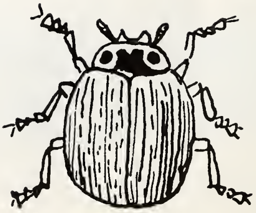


Plate VII. Dorsal views of right halves of lady beetles. 1, *Coleomegilla maculata lengi*; 2, *C. m. fuscilabris*; 3, *Cycloneda sanguinea*; 4, *C. munda*; 5, *Adalia bipunctata*; 6, 7, *Hyperaspis signata*, ♂♂; 8, 9, *H. congressi*, ♂♂; 10, *H. binotata*, ♂; 11, *H. pratensis*, ♀; 12, *H. lateralis*, ♀; 13, *H. connectens*, ♀; 14, *H. pinorum*, ♂; 15, *H. bigeminata*, ♂; 16, *H. undulata*, ♀; 17, *Rodolia cardinalis*. (All figures are 9X.)



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Physical and Chemical Properties of Three Groups of Mississippi River Alluvial Soils In the Sugarcane Area of Louisiana

Ray Ricaud, L. E. Golden and S. A. Lytle[1]

INTRODUCTION

The soils of the Mississippi River Alluvium of the Yazoo area were originally classified as the Yazoo, Sharkey and Muck series (*4*).[2] The Yazoo and Muck series were discarded and Commerce and Mhoon were established as soil series with the result that the Commerce, Mhoon and Sharkey are three of the Recent Alluvial soils in the Mississippi River floodplain (*12, 21*).

The initial intent in this study was to include only soils classified as Commerce, Mhoon and Sharkey during the sampling period from 1965 to 1969. However, recent refinements in soil classification indicate that additional associated soils were included (*22*). Therefore, for the purpose of this publication, the soils were referred to as Commerce group soils, Mhoon group soils and Sharkey group soils. These groupings facilitate the presentation of the results and are consistent with the manner in which the soils were grouped at the time of sampling. They do not reflect a strict grouping by soil series, since each of the three groups may contain soils from series other than the one used in naming the groups.

The Recent Alluvial soils in the sugarcane area were deposited by floodwaters of the Mississippi River and Bayou Lafourche from the time the Mississippi began to flow in its present channel approximately 3,000 years ago (*5*) until the construction of flood control systems during the early part of this century. The coarser-textured Commerce group soils are moderately well drained and occur on natural levees near the overflowing streams. The Mhoon group soils are nearly level and not as well drained as the Commerce. The finer-textured Sharkey group soils are poorly drained and occur in and near the "back-swamps" farthest from the streams.

Previous work (*6, 7, 16, 19*) showed that wide variations occurred in the extractable nutrient content and in the response of sugarcane to applied fertilizers in Recent Alluvial soils. Reed and Sturgis (*15*) reported that soils with a high clay content generally had a higher nutrient content in the subsoil than in the topsoil and that deep-rooted plants assimilated large amounts of nutrients from the subsoil.

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[2] Italic numbers in parentheses refer to Literature Cited, Page 55.

Ricaud (*16*) obtained a significant relationship between extractable potassium and the increase in yield of sugarcane from applied fertilizer potassium. Golden (*6*) found that the increase in yield of sugarcane from applied fertilizer phosphorus was greater on fine-textured than on coarse-textured soils, apparently due to the restricted aeration and root penetration in fine-textured soils. Abdol (*1*) reported that during a 13-year period beginning in 1960 the steady depletion rates of soil nutrients in Mhoon soils were substantially greater than the amounts removed by sugarcane.

Sturgis and McMichael (*20*) found that soils with a low clay content exhibited more profile development than did soils with a high clay content. Shuker (*17*) reported that more horizon development occurred in the Mississippi River Terrace soils than in the Recent Alluvial soils.

Jeffries (*11*) concluded that soils of similar origin can be determined on the basis of their mineralogical properties. Holmes and Hearn (*8*) concluded that the Recent Alluvial soils were derived primarily from the eastern slopes of the Rocky Mountains and the Great Plains.

The primary objective of this study was to determine the variations in the physical and chemical properties that occur within and among the Commerce, Mhoon and Sharkey groups of soils in the sugarcane area of Louisiana. The results should contribute to the soil fertility maintenance programs and management of these soils.

MATERIALS AND METHODS

The Commerce, Mhoon and Sharkey groups of soils were sampled at 28, 30 and 24 locations, respectively, during the period from 1965 to 1969. The locations, shown in Table 1, were selected to represent the sugarcane producing parishes in the Lower Mississippi River floodplain in Louisiana. The area sampled extends from West Feliciana Parish, along the Mississippi River to St. Charles Parish and along Bayou Lafourche from its origin in Ascension Parish to Terrebonne Parish. Soil profile samples were collected from the Ap, A-C and C horizons of each soil during the fallow year in a sugarcane production cycle. The horizon designation and soil structure, consistency and color of each sample were determined in accordance with standard procedures (*18*). Percentages of sand, silt and clay in the soil were determined by the hydrometer method (*13*).

The extractable potassium, calcium, magnesium and sodium were extracted with a 0.1 *N* hydrochloric acid solution at a soil-to-solution ratio of 1:20. The exchangeable bases were extracted by the ammonium acetate method (*14*). The total bases were extracted by using the hydrofluoric acid method described by Jackson (*10*). The concentrations of the extractable, exchangeable and total bases were determined with a

Beckman Model DU flame spectrophotometer (*9*). Exchangeable hydrogen was determined by the barium acetate titration method (*10*).

Sulphur was extracted with a solution of 0.5 *N* ammonium acetate and 0.25 *N* acetic acid and determined according to the modified turbidity method of Bardsley and Lancaster (*2*). Total soil nitrogen was determined by the Kjeldahl method (*10*). Organic carbon was obtained by the Walkley-Black wet combustion method (*23*).

The cation exchange capacity of the soil was obtained by summation of the exchangeable potassium, sodium, calcium, magnesium and hydrogen. Percent base saturation was calculated by dividing the total exchangeable bases by the cation exchange capacity and multiplying by 100. Soil reaction (pH) was measured in a soil-to-water ratio of 1:1 using a Beckman Zeromatic pH meter.

Table 1.-Locations selected for sampling three groups of Mississippi River alluvial soils in the sugarcane area of Louisiana.[1]

Location number	Commerce group soils		Mhoon group soils		Sharkey group soils	
	Plantation	Parish	Plantation	Parish	Plantation	Parish
1	Angola	W. Feliciana	Angola	W. Feliciana	Catherine	W. B. R.
2	Bonaventure	P. Coupee	Angola	W. Feliciana	P. Grove	W. B. R.
3	Alma	P. Coupee	Sugarland	P. Coupee	Cinclare	W. B. R.
4	Smithfield	W. B. R.	Alma	P. Coupee	M. Grove	Iberville
5	Smithfield	W. B. R.	Smithfield	W. B. R.	Evergreen	Iberville
6	Barrowza	W. B. R.	Westover	W. B. R.	C. Grove	Iberville
7	Barrowza	W. B. R.	P. Grove	W. B. R.	E. Hall	Ascension
8	Cinclare	W. B. R.	Cinclare	W. B. R.	Palo Alto	Ascension
9	Cinclare	W. B. R.	St. Louis	Iberville	Graugnard	St. James
10	Ben Hur	E. B. R.	C. Grove	Iberville	Helvetia	St. James
11	M. Grove	Iberville	L. Landry	Iberville	Armant	St. James
12	L. Ridge	Iberville	E. Hall	Ascension	Frisco	St. John
13	L. Ridge	Iberville	Sunshine	Ascension	Lula	Assumption
14	Alahambre	Iberville	Palo Alto	Ascension	Westfield	Assumption
15	McManor	Ascension	St. Mary	St. James	Glenwood	Assumption
16	E. Hall	Ascension	Gravois	St. James	C. Grove	Assumption
17	Stein	St. James	Graugnard	St. James	Leighton	Lafourche
18	Graugnard	St. James	Frisco	St. John	Mary	Lafourche
19	Armant	St. James	Chilton	St. John	Georgia	Lafourche
20	Columbia	St. John	Lula	Assumption	Valentine	Lafourche
21	Whitney	St. John	Glenwood	Assumption	Cynthia	Terrebonne
22	Goldmine	St. John	Harang	Assumption	Southdown	Terrebonne
23	Reserve	St. Charles	Caldwell	Lafourche	Ashland	Terrebonne
24	Waterford	St. Charles	Raceland	Lafourche	M. Grove	Terrebonne
25	Avon	Assumption	Georgia	Lafourche		
26	L. Texas	Assumption	Georgia	Lafourche		
27	Georgia	Lafourche	Caldwell	Terrebonne		
28	Argyle	Terrebonne	Southdown	Terrebonne		
29			R. Cox	Terrebonne		
30			Montegut	Terrebonne		

---

[1] The Commerce, Mhoon and Sharkey were sampled at 28, 30 and 24 locations, respectively.

DISCUSSION OF RESULTS

Variations in the chemical properties among locations in the Ap, A-C and C horizons of the Commerce, Mhoon and Sharkey groups of soils are summarized in Tables 2, 3, 4 and 5. The variations are expressed as ranges and means among locations for each horizon of each soil group. The detailed data obtained for each location are presented in the Appendix, Tables 6-10 for the Commerce, Tables 11-15 for the Mhoon and Tables 16-20 for the Sharkey group of soils.

Soil Physical Properties

The data obtained on the physical properties of the Commerce, Mhoon and Sharkey groups of soils are reported in the Appendix, Tables 6, 11 and 16, respectively.

The variations among locations in the textural class, structure, consistency and color of the soils within each group were relatively small. Soils in the Commerce group were predominantly granular, friable, dark grayish brown loams and silt loams in the Ap, A-C and C horizons. Soils in the Mhoon group were mostly granular, friable, dark grayish brown silt loams and silty clay loams in the Ap horizons and blocky to weak blocky, plastic, gray silty clay loams in the A-C and C horizons. Soils in the Sharkey group were predominantly blocky, plastic, dark gray clays in each horizon.

Soil Chemical Properties

Potassium and Sodium

The potassium and sodium data reported in Table 2 are summarized from the Appendix, Tables 7, 12 and 17. Wide ranges were obtained among locations in the extractable and exchangeable potassium and sodium contents in each horizon of the three soil groups. Extractable potassium in the Ap horizon ranged from 82 to 239 ppm in the Commerce, from 90 to 420 ppm in the Mhoon and from 172 to 367 ppm in the Sharkey group. Similar ranges occurred in the A-C and C horizons and in the exchangeable potassium in each horizon. The mean differences among horizons in each group were small. The mean values in each horizon were lowest in the Commerce and highest in the Sharkey group, due mainly to the clay content. Relatively narrow ranges were obtained in the total potassium among locations, horizons and soil groups. The extractable potassium was a very small percentage of the total potassium in all the soils. The sodium values were lower, but varied similarly to potassium, except that the extractable and exchangeable sodium increased consistently with depth.

Table 2.-Potassium and sodium contents among locations in each horizon of three groups of Mississippi River alluvial soils.

Soil horizon	Commerce group		Mhoon group		Sharkey group	
	Range	Mean	Range	Mean	Range	Mean
			Extractable K, ppm			
Ap	82-239	130	90-420	204	172-367	246
A-C	72-191	112	124-322	214	158-284	234
C	70-193	117	140-316	219	192-288	238
			Exchangeable K, ppm			
Ap	89-226	140	127-588	255	216-528	355
A-C	67-212	105	143-395	267	173-488	356
C	55-157	107	144-442	280	223-471	358
			Total K, percent			
Ap	1.65-2.04	1.90	1.66-2.14	1.84	1.44-2.04	1.74
A-C	1.80-2.18	1.97	1.68-2.37	1.90	1.46-1.99	1.74
C	1.72-2.16	1.97	1.66-2.27	2.20	1.40-2.05	1.79
			Extractable Na, ppm			
Ap	10-221	54	50-246	79	66-161	103
A-C	15-139	81	62-176	104	72-225	143
C	21-179	85	72-186	115	124-281	163
			Exchangeable Na, ppm			
Ap	12-179	44	22-249	62	39-224	80
A-C	14-115	63	32-218	81	51-188	96
C	15-159	67	34-272	92	71-200	113
			Total Na, percent			
Ap	1.08-1.45	1.28	1.16-1.82	1.35	0.98-1.47	1.13
A-C	0.98-1.46	1.23	1.08-1.76	1.31	0.93-1.36	1.15
C	1.06-1.73	1.24	0.96-1.54	1.26	0.95-1.36	1.19

Calcium and Magnesium

The calcium and magnesium data reported in Table 3 are summarized from the Appendix, Tables 8, 13 and 18. Wide ranges were found among locations in the extractable and exchangeable calcium and magnesium contents in each horizon of the three soil groups. Extractable calcium in the Ap horizon ranged from 1,115 to 7,123 ppm in the Commerce, from 1,738 to 3,784 ppm in the Mhoon and from 3,768 to 6,495 ppm in the Sharkey group. Similar variations occurred in the other horizons. The extractable was higher than the exchangeable calcium only in the Commerce, indicating the presence of relatively more acid soluble calcium in the coarser-textured soils. The mean values

Table 3.-Calcium and magnesium contents among locations in each horizon of three groups of Mississippi River alluvial soils.

Soil horizon	Commerce group		Mhoon group		Sharkey group	
	Range	Mean	Range	Mean	Range	Mean
			Extractable Ca, ppm			
Ap	1115-7123	2475	1738-3784	2606	3768-6495	4900
A-C	1527-13350	4467	2444-6431	3465	3749-6480	5092
C	1942-14750	5256	2349-5523	3730	3635-6653	5113
			Exchangeable Ca, ppm			
Ap	1038-3531	1947	2200-3798	3056	1301-7508	5707
A-C	1308-4188	2931	2642-5535	3951	5010-8071	6200
C	1031-4615	2985	27-7-5829	4153	4851-9401	6254
			Total Ca, percent			
Ap	0.64-1.42	0.97	0.54-1.09	0.72	0.61-1.38	0.99
A-C	0.70-1.73	1.02	0.54-1.47	0.80	0.67-1.49	1.11
C	0.67-1.72	1.10	0.51-1.41	0.83	0.80-1.84	1.23
			Extractable Mg, ppm			
Ap	183-1587	409	413-1134	636	797-1313	1079
A-C	267-2209	773	653-1898	978	970-1598	1250
C	268-2495	1025	644-1468	1085	933-1899	1343
			Exchangeable Mg, ppm			
Ap	259-777	407	356-1169	638	896-1598	1193
A-C	380-964	630	447-1360	862	960-1663	1337
C	315-865	644	319-1252	910	845-1724	1340
			Total Mg, percent			
Ap	0.39-0.87	0.63	0.39-0.69	0.54	0.61-1.03	0.81
A-C	0.44-1.02	0.81	0.51-1.05	0.76	0.80-1.10	0.92
C	0.47-1.11	0.81	0.51-1.05	0.76	0.80-1.10	0.92

for each horizon increased with depth in the soil, particularly in the Commerce. The values were lowest in the Commerce and highest in the Sharkey group. Relatively small variations occurred in the total calcium among the locations, horizons and soil groups. The magnesium content was lower, but varied similarly to the calcium values.

Phosphorus, Sulphur, Carbon and Nitrogen

The phosphorus, sulphur, organic carbon and nitrogen data reported in Table 4 are summarized from the Appendix, Tables 9, 14 and 19. Wide ranges occurred among locations in extractable and total phosphorus content in each horizon of the three soil groups. Extractable phosphorus in the Ap horizon ranged from 135 to 627 ppm in the Commerce, from 143 to 521 ppm in the Mhoon and from 124 to 992 ppm in the Sharkey group. The mean differences were relatively small among horizons in each soil group and among soil groups in each horizon. Almost one-half of the total phosphorus was in the extractable fraction. Only a small portion of the phosphorus extracted by the method used is actually available for uptake by plants. Extractable sulphur determined by the method described by Bardsley and Lancaster (2) was very low, and the differences among locations, horizons and soil groups were small.

The data in Table 4 also show the variations in organic carbon and total nitrogen that occurred among locations, horizons and soil groups.

Table 4.-Phosphorus, sulphur, carbon and nitrogen contents among locations in each horizon of three groups of Mississippi River alluvial soils.

Soil	Commerce group		Mhoon group		Sharkey group	
horizon	Range	Mean	Range	Mean	Range	Mean
Extractable P, ppm						
Ap	135-627	299	143-521	269	124-992	264
A-C	136-1100	295	143-402	245	95-600	217
C	211-1320	323	140-372	264	106-313	216
Total P, ppm						
Ap	350-883	528	344-999	558	483-1529	807
A-C	409-1287	589	415-867	523	373-939	607
C	366-1383	600	249-690	520	398-956	593
Extractable S, ppm						
Ap	4-18	7	4-16	9	6-28	12
A-C	2-11	6	4-18	6	4-18	9
C	1-18	6	2-16	6	4-12	7
Organic C, percent						
Ap	0.29-1.09	0.64	0.43-1.61	1.05	1.54-2.73	2.01
A-C	0.28-0.83	0.46	0.27-1.19	0.65	0.74-2.36	1.18
C	0.19-0.81	0.38	0.25-0.91	0.49	0.44-1.94	0.92
Total N, percent						
Ap	0.03-.10	0.06	0.05-.20	0.11	0.11-.19	0.15
A-C	0.03-.08	0.05	0.03-.12	0.07	0.07-.16	0.11
C	0.02-.08	0.04	0.04-.10	0.06	0.07-.16	0.09
C/N Ratio						
Ap	7.9-12.3	10.0	8.6-12.0	9.8	11.4-14.9	13.4
A-C	6.9-13.4	9.5	6.9-10.9	8.7	8.9-16.3	11.5
C	5.0-13.9	9.8	5.0-10.4	8.0	7.8-14.2	10.5

Organic matter, obtained by multiplying organic carbon by 1.724, ranged in the Ap horizon from 0.50 to 1.88 percent in the Commerce, from 0.74 to 2.78 percent in the Mhoon and from 2.65 to 4.71 percent in the Sharkey group. Organic matter and total nitrogen were lowest in the Commerce and highest in the Sharkey, and decreased with depth in the soil in each of the groups. The carbon-nitrogen ratio varied considerably among locations in each horizon of the three soil groups. The mean ratio in the Ap horizon was 10.0, 9.8, 13.4 in the Commerce, Mhoon and Sharkey groups, respectively.

Clay, Exchange Properties and Soil Reaction (pH)

The clay content, exchange properties and pH values summarized in Table 5 are shown in detail in the Appendix, Tables 10, 15 and 20.

Table 5.-Clay content, exchange properties and soil reaction among locations in each horizon of three groups of Mississippi River alluvial soils.

Soil	Commerce group		Mhoon group		Sharkey group	
horizon	Range	Mean	Range	Mean	Range	Mean
			Clay, percent			
Ap	8.9-25.5	14.4	11.5-56.6	26.0	33.4-73.5	57.4
A-C	12.8-31.5	21.7	14.2-66.7	35.6	34.9-78.0	63.7
C	8.8-30.0	20.5	15.5-57.9	37.8	50.0-79.9	63.5
			Cation Exchange Capacity, m.e./100g			
Ap	9.4-23.0	14.6	16.0-37.1	23.5	32.3-50.9	42.4
A-C	10.5-28.6	21.0	17.4-41.6	28.9	33.4-50.7	43.5
C	9.0-29.9	21.2	19.8-41.1	30.0	33.9-59.5	43.3
			Exchangeable H, m.e./100g			
Ap	.0-3.1	1.0	.0-4.4	2.0	1.1-4.5	3.0
A-C	.0-3.0	.7	.0-2.3	.9	.0-2.8	1.2
C	.0-2.2	.4	.0-1.7	.5	.0-2.6	.7
			Exchangeable Bases, m.e./100g			
Ap	7.7-22.8	13.6	15.3-35.1	21.5	30.4-47.9	39.4
A-C	10r5-28.6	20.4	17.4-40.4	28.0	32.0-50.7	42.3
C	9.0-29.9	20.8	18.7-40.5	29.5	32.4-59.5	42.6
			Base Saturation, percent			
Ap	80.4-100	93.2	80.6-100	91.6	88.4-97.2	93.0
A-C	85.0-100	97.1	91.2-100	96.6	94.7-100	97.1
C	88.7-100	98.1	91.6-100	98.0	93.9-100	98.2
			Soil Reaction (pH)			
Ap	5.1-8.2	-	5.3-7.6	-	5.9-7.3	-
A-C	6.1-8.2	-	6.2-7.7	-	6.3-7.6	-
C	6.2-8.3	-	6.5-7.7	-	6.5-7.7	-

Wide ranges were found in the clay content of the soils among locations in each horizon of the three soil groups and among the soil groups. Similar variations were found in the cation exchange capacity and exchangeable bases associated with the clay content. The percent base saturation and pH values varied substantially among locations and increased with depth in the profiles.

SUMMARY AND CONCLUSIONS

A study was made of the physical and chemical properties of the Commerce, Mhoon and Sharkey groups of soils in the sugarcane area of Louisiana. Soil profile samples were collected from the Ap, A-C and C horizons of each soil group at several locations. The samples were analyzed to determine the variations in the soil properties among horizons, locations and soil groups.

Relatively small variations were found in the soil textural class, structure, consistency and color among locations in each soil group. Wide ranges occurred in these physical properties among the soil groups in each horizon and among horizons in the Mhoon. The ranges among horizons in the Commerce and Sharkey groups were small.

Wide variations were obtained in the extractable and exchangeable bases, extractable and total phosphorus, carbon-nitrogen ratio, soil reaction (pH) and exchange properties of the soil in each horizon of each soil group at different locations. Moderate ranges in organic matter and total nitrogen content and narrow ranges in the total bases and extractable sulphur were found among locations in each soil group.

The extractable calcium and magnesium, soil reaction (pH) and exchange properties increased substantially with increasing depth of the horizons in each group; the organic matter and total nitrogen decreased. The extractable bases, clay content and exchange capacity were lowest in the Commerce, intermediate in the Mhoon and highest in the Sharkey group. The variations in the other chemical data were relatively small among horizons and among the three groups of soils.

APPENDIX

Table 6 .-Physical properties of Commerce group soils.

Loc. No. and Horizon	Texture[1]	Depth, Inches	Structure[2]	Consistency[3]	Color[4]
1Ap	l	0-10	Weak coarse granular	Friable	Dr.gr.br.
A-C	l	11-20	Weak coarse granular	Friable	Br.mot.gr.
C	l	21-30	Weak coarse granular	V. friable	Br.mot.gr.
2Ap	sil	0-9	Med. coarse granular	Friable	Dr.gr.br.
A-C	l	10-20	Med.subang.blocky	Sli.plastic	Dr.br.mot.gr.
C	cl	21-30	Mod.med.subang.blocky	Sli.plastic	Br.mot.gr.
3Ap	sil	0-8	Weak granular	Friable	Dr.gr.br.
A-C	sil	10-20	Pla.and weak subang.blocky	Friable	Dr.Br.
C	l	21-30	Weak subang.blocky	Friable	Dr.gr.br.mot.gr.
4Ap	sl	0-11	Weak coarse granular	Friable	Dr.gr.br.
A-C	l	12-20	Weak subang.blocky	Friable	Dr.gr.br.mot.dr.br.
C	l	21-30	Blocky	Sli.plastic	Dr.gr.mot.gr. & br.
5Ap	sil	0-10	Mod.med. and fine granular	Friable	Dr.gr.br.
A-C	l	11-20	Mod. fine subang. blocky	Friable	Dr.gr.br.mot.dr.br.
C	l	21-30	Fine subang.blocky	Friable	Dr.gr.mot.dr.br.
6Ap	sl	0-10	Weak granular	V. friable	Dr.gr.br.
A-C	sl	11-20	Weak fine subang.blocky	Friable	Dr.br.
C	ls	21-30	Weak fine subang.blocky	Friable	Dr.br.mot.gr.
7Ap	sl	0-9	Weak fine granular and pla.	Friable	Dr.gr.br.
A-C	l	10-20	Weak subang.blocky	Friable	Dr.gr.br.mot.gr.
C	cl	21-30	Weak subang.blocky	Sli.plastic	Dr.gr.br.mot.gr. & br.

(Continued)

Table 6 .-(Continued) Physical properties of Commerce group soils.

Loc. No. and Horizon	Texture1/	Depth, Inches	Structure2/	Consistency3/	Color4/
8Ap	sil	0-8	Weak granular	Friable	Dr.gr.br.
A-C	sil	9-20	Weak subang.blocky	Friable	Dr.gr.br.
C	sil	21-30	Weak subang.blocky	Friable	Dr.gr.mot.br. & gr.br.
9Ap	sil	0-8	Med.fine granular	Friable	Dr.gr.br.
A-C	sil	10-20	Weak pla. and weak subang.blocky	Sli.plastic	Dr.gr.br.mot.gr. & br.
C	sil	21-30	Weak subang.blocky	Friable	Gr.mot.v.dr.br.
10Ap	l	0-8	Granular	Friable	Dr.gr.br.
A-C	l	9-20	Weak blocky	Friable	Br.mot.gr.br.
C	l	21-30	Blocky	Friable	Br.mot.gr.
11Ap	sil	0-12	Weak coarse blocky	Friable	V.dr.gr.br.
A-C	cl	13-20	Weak granular	Friable	Dr.br.mot.gr.
C	sil	21-30	Weak coarse granular	Friable	Gr.lenses dr.br.
12Ap	sil	0-10	Weak coarse granular	Friable	Dr.gr.br.
A-C	sicl	11-20	Strongly pla.and blocky	Sli.plastic	Dr.br.
C	sil	21-30	Strongly pla.and blocky	Sli.plastic	Br.gr.mot.dr.gr.br.
13Ap	sil	0-9	Granular	Friable	Dr.gr.br.
A-C	sil	10-20	Blocky	Friable	Br.mot.gr.br.
C	sil	21-30	Blocky	Friable	Dr.gr.br.mot.br. & gr.
14Ap	sil	0-10	Granular	Friable	Dr.gr.br.
A-C	sil	11-20	Blocky	Friable	Dr.gr.br.
C	sil	21-30	Blocky	Friable	Gr.mot.dr.gr.br.

(Continued)

Table 6 .-(Continued) Physical properties of Commerce group soils.

Loc. No. and Horizon	Texture 1/	Depth, Inches	Structure 2/	Consistency 3/	Color 4/
15Ap	sil	0-9	Weak med.granular	Friable	V.dr.gr.br.
A-C	l	10-20	Weak coarse granular	Friable	Dr.gr.br.mot.gr.
C	sl	21-30	Weak coarse granular	Friable	Br.mot.dr.gr.br. & gr.
16Ap	sil	0-8	Granular	Friable	Dr.gr.br.
A-C	sicl	9-19	Blocky	Friable	Br.mot.gr.br.
C	sil	20-30	Blocky	Friable	Gr.br.mot.gr.
17Ap	sil	0-9	Granular	Friable	Br.
A-C	sil	10-20	Pla. and blocky	Sli.plastic	Gr.br.
C	cl	21-30	Blocky	Plastic	Gr.mot.dr.gr.
18Ap	sl	0-12	Med.coarse and fine granular	Friable	Dr.gr.br.
A-C	l	13-20	Weak med.subang.blocky	Friable	Dr.br.mot.gr.
C	l	21-30	Weak med.subang.blocky	Friable	Yel.br.mot.gr.
19Ap	sil	0-10	Mod.med.and fine granular	Friable	Dr.gr.br.
A-C	sil	11-20	Weak med.blocky	Sli.plastic	Br.mot.gr. & dr.gr.
C	sil	21-30	Weak med.subang.blocky	Sli.plastic	Dr.br.mot.gr.
20Ap	sil	0-12	Weak fine granular	Friable	Dr.gr.br.
A-C	sil	13-20	Weak fine subang.blocky	Friable	V.dr.gr.br.
C	sil	21-30	Weak fine subang.blocky	Friable	V.dr.gr.br.
21Ap	sil	0-12	Granular	Friable	Dr.gr.br.
A-C	sicl	13-22	Weak blocky	Friable	Gr.br.mot.gr.
C	sil	23-30	Weak blocky	Friable	Br.mot.gr.

(Continued)

Table 6 .-(Continued) Physical properties of Commerce group soils.

Loc. No. and Horizon	Texture1/	Depth, Inches	Structure2/	Consistency3/	Color4/
22Ap	sl	0-9	Granular	Friable	Dr.gr.br.
A-C	l	10-19	Weak blocky	Friable	Dr.gr.br.
C	sl	20-30	Weak blocky	Friable	Br.mot.gr.
23Ap	sil	0-10	Fine granular	Friable	Dr.br.
A-C	sicl	11-20	Weak fine subang.blocky	Sli.plastic	Br.mot.gr. & dr.gr.
C	sicl	21-30	Weak med.subang.blocky	Friable	Gr.mot.dr.gr. & br.
24Ap	sil	0-12	Mod.med.granular	Friable	V.dr.gr.br.
A-C	sicl	13-20	Med.fine subang.blocky	Sli.plastic	Br.mot.dr.gr.
C	sil	21-30	Weak med.subang.blocky	Friable	Br.mot.gr.
25Ap	sil	0-8	Granular	Friable	Dr.gr.br.
A-C	sil	9-20	Blocky	Friable	Br.mot.gr.br.
C	l	21-30	Weak blocky	Friable	Br.mot.gr.br.
26Ap	sil	0-11	Mod.med.and fine granular	Friable	Br.
A-C	sil	12-20	Weak med.subang.blocky	Friable	Br.mot.dr.br. & dr.gr.
C	sil	21-30	Weak med.subang.blocky	Friable	Br.mot.gr.
27Ap	l	0-9	Med.finegranular	Friable	Dr.br.
A-C	sil	10-20	Weak fine subang.blocky	Friable	Br.mot.gr.
C	sil	21-30	Med.fine subang.blocky	Friable	Gr.mot.br.
28Ap	sil	0-12	Mod.fine granular	Friable	Dr.gr.
A-C	sil	13-20	Med.fine subang.blocky	Friable	Br.mot.gr.
C	sil	21-30	Mod.med.subang.blocky	Sli.plastic	Gr.mot.br.

1/sl = sandy loam; l = loam; sil = silt loam; sicl = silty clay loam; cl = clay loam.

2/med. = medium; mod. = moderately; subang. = subangular; pla. = platy.

3/v. = very; sli. = slightly.

4/v. = very; dr. = dark; gr. = gray, grayish; br. = brown; mot. = mottled.

Table 7.-Potassium and sodium contents of the Commerce group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
1A$_p$	238	226	1.76	22	12	1.44
A-C	115	85	1.80	23	14	1.46
C	106	65	1.82	37	17	1.40
2A$_p$	146	140	1.84	27	28	1.45
A-C	111	98	1.92	99	83	1.44
C	133	128	1.90	115	98	1.73
3A$_p$	117	121	1.86	19	20	1.40
A-C	131	123	2.00	60	52	1.32
C	116	96	1.93	55	44	1.36
4A$_p$	132	110	1.80	27	18	1.38
A-C	123	105	1.93	51	37	1.32
C	119	130	1.98	47	49	1.28
5A$_p$	188	192	1.84	41	25	1.21
A-C	133	117	1.94	46	37	1.19
C	138	128	2.01	59	44	1.28
6A$_p$	91	92	1.78	36	13	1.25
A-C	89	88	1.80	15	17	1.26
C	72	55	1.72	21	15	1.28
7A$_p$	105	91	1.81	32	27	1.25
A-C	122	96	1.95	55	43	1.40
C	179	157	1.92	64	56	1.32
8A$_p$	91	106	1.88	46	62	1.44
A-C	102	110	2.02	133	115	1.42
C	118	131	2.14	179	159	1.45
9A$_p$	117	130	1.92	40	43	1.36
A-C	138	147	1.93	68	77	1.28
	170	146	1.98	87	75	1.23
10A$_p$	117	128	1.84	221	179	1.18
A-C	76	67	1.97	121	96	1.09
C	88	75	1.95	123	90	1.08

(Continued)

Table 7.-(Continued) Potassium and sodium contents of the Commerce group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
11A_p	239	231	2.02	33	27	1.30
A-C	126	124	2.04	69	54	1.29
C	97	97	1.99	46	58	1.32
12A_p	125	143	1.95	37	62	1.36
A-C	124	132	1.92	73	84	1.25
C	147	111	1.90	64	70	1.23
13A_p	112	133	1.97	67	49	1.26
A-C	101	98	1.95	87	67	1.20
C	127	121	2.00	88	66	1.13
14A_p	106	131	1.95	98	58	1.24
A-C	93	86	1.92	99	73	1.13
C	109	111	1.98	100	77	1.15
15A_p	124	132	1.98	33	54	1.19
A-C	102	99	1.88	51	60	1.10
C	96	68	1.86	37	46	1.12
16A_p	162	203	2.04	64	42	1.17
A-C	112	121	2.09	84	57	1.13
C	119	100	2.10	104	62	1.15
17A_p	85	113	1.92	55	41	1.08
A-C	81	74	2.09	97	54	1.07
C	104	107	2.04	100	66	1.19
18A_p	82	89	1.65	10	49	1.28
A-C	81	85	1.83	87	96	1.19
C	81	93	1.78	105	125	1.20
19A_p	164	197	1.95	37	63	1.25
A-C	113	131	2.18	72	69	1.21
C	125	146	2.16	83	76	1.23
20A_p	92	107	1.92	72	51	1.20
A-C	83	79	1.90	139	89	1.26
C	70	70	1.98	139	110	1.19

(Continued)

Table 7.-(Continued) Potassium and sodium contents of the Commerce group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
$21A_p$	143	172	1.95	46	28	1.08
A-C	140	107	2.04	73	37	1.05
C	118	83	1.93	64	37	1.06
$22A_p$	142	194	1.92	41	25	1.36
A-C	72	69	1.95	59	42	1.32
C	72	59	1.90	67	39	1.21
$23A_p$	96	114	1.86	55	49	1.19
A-C	115	131	2.00	132	105	1.04
C	119	147	2.02	131	107	1.21
$24A_p$	202	225	1.98	64	32	1.22
A-C	191	212	2.09	88	54	0.98
C	193	199	2.04	83	52	1.06
$25A_p$	106	96	1.98	98	78	1.35
A-C	118	79	2.04	86	51	1.32
C	122	91	2.05	67	39	1.28
$26A_p$	106	116	2.01	67	43	1.24
A-C	110	101	2.02	99	72	1.20
C	83	83	2.04	92	69	1.21
$27A_p$	117	96	1.84	71	23	1.22
A-C	140	79	1.92	92	38	1.24
C	166	104	1.88	123	56	1.19
$28A_p$	86	92	1.95	59	39	1.40
A-C	93	107	2.09	122	77	1.17
C	97	104	2.11	106	72	1.20

Table 8.-Calcium and magnesium contents of the Commerce group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
1A$_p$	4255	1429	0.92	1024	363	0.53
A-C	6653	1925	0.86	1351	543	0.56
C	8050	1948	1.18	1927	423	0.55
2A$_p$	1181	1038	0.64	213	243	0.52
A-C	2786	2920	0.70	419	564	0.57
C	3024	3191	0.67	521	735	0.74
3A$_p$	1177	1086	1.01	183	259	0.72
A-C	2681	2620	1.02	464	583	0.81
C	1942	1708	1.09	327	450	0.70
4A$_p$	1924	1225	1.15	208	273	0.57
A-C	1890	2198	1.16	421	616	0.83
C	2579	2729	0.94	558	812	0.84
5A$_p$	4369	2206	1.18	940	546	0.75
A-C	7482	2726	1.29	1640	561	0.88
C	7586	2911	1.33	1640	575	0.86
6A$_p$	1414	1162	1.00	303	409	0.54
A-C	1527	1308	1.11	325	446	0.70
C	2881	1031	1.15	829	440	0.80
7A$_p$	3237	1143	1.18	840	389	0.46
A-C	7844	2111	1.38	1673	520	0.81
C	8823	3323	1.29	1641	706	0.92
8A$_p$	1320	1422	0.97	301	340	0.58
A-C	1946	2172	0.90	383	523	0.77
C	2371	4185	0.92	501	670	0.81
9A$_p$	1575	1829	0.86	223	381	0.54
A-C	4652	4022	1.04	619	665	0.79
C	9050	4319	1.49	1769	576	0.94
10A$_p$	1590	1844	0.79	252	420	0.72
A-C	2273	2615	0.78	444	703	0.87
C	2403	2749	0.77	575	836	0.93

(Continued)

Table 8.-(Continued) Calcium and magnesium contents of the Commerce group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
11A$_p$	1742	1781	1.02	209	326	0.49
A-C	2964	3058	0.89	468	671	0.82
C	2377	2749	0.94	393	630	0.78
12A$_p$	2046	2189	0.97	266	419	0.67
A-C	3737	3489	0.85	633	734	0.88
C	8944	4205	1.52	1846	549	0.84
13A$_p$	2142	2213	1.01	261	387	0.70
A-C	2952	3010	1.07	493	624	0.79
C	5449	3406	1.12	1079	796	1.11
14A$_p$	2355	2561	1.00	359	507	0.86
A-C	3956	3008	0.89	498	623	0.95
C	3545	3255	0.86	703	777	0.98
15A$_p$	2938	2887	1.01	402	531	0.71
A-C	5065	2602	1.18	1147	599	0.75
C	6310	1650	1.31	1324	412	0.79
16A$_p$	3309	3268	0.97	408	574	0.86
A-C	3640	4013	0.89	578	751	1.02
C	8456	3623	1.18	1608	767	1.08
17A$_p$	1578	1670	1.02	214	331	0.57
A-C	3005	3099	0.94	461	623	0.79
C	3553	3490	1.03	575	799	0.76
18A$_p$	1115	1398	0.72	201	339	0.39
A-C	2372	2627	0.78	527	781	0.44
C	2544	2648	0.77	558	827	0.47
19A$_p$	2352	2382	0.86	349	544	0.43
A-C	3240	3208	0.81	458	686	0.50
C	3325	3367	0.80	483	759	0.54
20A$_p$	1883	1905	0.78	210	333	0.50
A-C	3392	2611	0.89	267	380	0.56
C	3293	2572	0.86	268	427	0.54

(Continued)

Table 8.-(Continued) Calcium and magnesium contents of the Commerce group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
21A_p	3570	2275	1.13	796	685	0.73
A-C	8795	4188	1.48	1885	879	0.84
C	9163	4057	1.72	1808	519	0.83
22Ap	1419	1419	1.05	208	355	0.51
A-C	2655	2226	1.06	403	531	0.48
C	4366	1796	1.26	979	469	0.59
23A_p	1431	1636	0.65	210	344	0.64
A-C	3250	3547	0.72	483	819	0.90
C	3142	3356	0.68	524	865	0.88
24A_p	2556	2638	1.01	266	455	0.52
A-C	3873	3709	0.75	597	964	0.82
C	5372	3354	1.02	973	756	0.74
25Ap	6207	3531	1.24	672	560	0.87
A-C	11880	3832	1.73	1803	451	0.96
C	8526	2354	1.60	1796	315	1.04
26A_p	1748	1789	0.73	235	419	0.75
A-C	4653	3143	0.97	491	648	0.76
C	2778	2470	1.02	423	617	0.77
27A_p	7123	2707	1.42	1587	321	0.71
A-C	13350	3453	1.69	2209	426	0.75
C	14750	4615	1.56	2495	769	0.92
28A_p	1744	1878	0.81	225	352	0.74
A-C	2553	2637	0.75	507	716	0.90
C	2562	2526	0.77	575	751	0.94

Table 9.-Phosphorus, sulphur, carbon and nitrogen contents of the Commerce group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	
1Ap	596	728	4.1	0.514	0.048	10.7
A-C	310	546	3.7	0.276	0.028	9.9
C	303	601	2.9	0.289	0.024	12.0
2Ap	385	595	5.5	0.394	0.050	7.9
A-C	322	661	2.5	0.431	0.052	8.3
C	264	574	3.7	0.436	0.051	8.5
3Ap	267	441	6.1	0.387	0.048	8.1
A-C	217	511	6.1	0.398	0.051	7.8
C	297	508	7.1	0.189	0.032	5.9
4Ap	326	519	6.3	0.389	0.046	8.5
A-C	268	562	6.5	0.427	0.047	9.1
C	252	597	6.5	0.502	0.056	9.0
5Ap	341	562	12.3	0.704	0.067	10.5
A-C	293	583	7.1	0.389	0.036	10.8
C	294	366	9.1	0.340	0.033	10.3
6Ap	274	452	4.9	0.460	0.048	9.6
A-C	271	511	4.1	0.427	0.048	8.9
C	276	527	5.2	0.294	0.033	8.9
7Ap	284	455	6.1	0.376	0.034	11.1
A-C	265	551	6.9	0.325	0.028	11.6
C	249	599	6.2	0.437	0.042	10.4
8Ap	242	436	7.6	0.294	0.035	8.4
A-C	241	511	6.9	0.279	0.039	7.2
C	300	532	5.1	0.274	0.034	8.1
9Ap	215	377	12.5	0.424	0.049	8.7
A-C	273	516	10.5	0.334	0.041	8.1
C	283	540	17.9	0.348	0.035	9.9
10Ap	171	404	8.6	0.638	0.076	8.4
A-C	136	409	11.2	0.561	0.062	9.0
C	229	556	13.5	0.321	0.031	10.4

(Continued)

Table 9.-(Continued) Phosphorus, sulphur, carbon and nitrogen contents of the Commerce group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	
11Ap	343	677	9.9	0.897	0.080	11.2
A-C	261	540	5.0	0.340	0.046	7.4
C	312	556	3.1	0.212	0.042	5.0
12Ap	231	420	6.2	0.781	0.073	10.7
A-C	263	527	3.6	0.402	0.049	8.2
C	276	441	7.4	0.363	0.034	10.7
13Ap	266	487	7.8	0.740	0.064	11.6
A-C	297	554	7.4	0.416	0.042	9.9
C	296	567	7.2	0.503	0.043	11.7
14Ap	254	495	6.6	0.789	0.074	10.7
A-C	290	572	6.4	0.563	0.049	11.5
C	325	575	6.1	0.444	0.039	11.4
15Ap	268	538	4.9	0.684	0.071	9.6
A-C	288	519	2.8	0.295	0.032	9.2
C	333	605	3.7	0.230	0.020	11.5
16Ap	293	631	4.7	1.089	0.102	10.7
A-C	239	597	6.1	0.702	0.064	11.0
C	281	602	4.5	0.522	0.043	12.1
17Ap	280	535	6.1	0.853	0.085	10.0
A-C	220	602	6.3	0.670	0.077	8.7
C	261	687	6.0	0.628	0.071	8.8
18Ap	168	350	6.4	0.541	0.048	11.3
A-C	169	500	5.0	0.405	0.042	9.6
C	250	564	5.9	0.302	0.031	9.7
19Ap	272	551	8.2	0.814	0.081	10.0
A-C	224	556	5.6	0.521	0.063	8.3
C	277	607	4.8	0.398	0.046	8.7
20Ap	627	883	9.2	0.832	0.083	10.0
A-C	1100	1287	6.8	0.828	0.083	10.0
C	1320	1383	5.0	0.810	0.080	10.1

(Continued)

Table 9.-(Continued) Phosphorus, sulphur, carbon and nitrogen contents of the Commerce group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	
21Ap	276	551	4.9	0.722	0.063	11.5
A-C	215	543	3.1	0.596	0.045	13.2
C	229	546	2.8	0.361	0.029	12.4
22Ap	390	615	6.7	0.688	0.063	10.9
A-C	347	629	6.4	0.630	0.057	11.1
C	337	682	6.3	0.339	0.031	10.9
23Ap	135	361	10.3	0.641	0.071	9.0
A-C	233	594	7.4	0.343	0.050	6.9
C	247	567	7.5	0.284	0.039	7.3
24Ap	383	583	17.5	0.680	0.074	9.2
A-C	432	776	8.6	0.628	0.071	8.8
C	440	712	9.0	0.452	0.045	10.0
25Ap	283	519	6.1	0.687	0.056	12.3
A-C	291	583	4.8	0.468	0.035	13.4
C	299	530	4.6	0.347	0.025	13.9
26Ap	249	503	5.4	0.608	0.066	9.2
A-C	283	618	1.6	0.361	0.041	8.8
C	335	615	1.4	0.283	0.027	10.5
27Ap	316	589	4.8	0.602	0.057	10.6
A-C	228	548	6.1	0.407	0.032	12.7
C	211	570	4.9	0.442	0.041	10.8
28Ap	243	530	3.7	0.684	0.073	9.4
A-C	273	599	4.8	0.416	0.042	9.9
C	282	597	4.6	0.381	0.039	9.8

Table 10.-Clay content, exchange properties, and pH of the Commerce group soils.

Loc. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./ 100g	m.e./ 100g	m.e./ 100g	%	
1Ap	8.9	10.77	-	10.77	100+	7.7
A-C	12.8	14.36	-	14.36	100+	8.0
C	12.7	13.44	-	13.44	100+	8.1
2Ap	10.1	9.49	1.83	7.66	80.7	5.3
A-C	24.6	21.60	1.77	19.83	91.8	6.2
C	30.0	24.21	1.48	22.73	93.9	6.2
3Ap	11.4	9.83	1.88	7.95	90.0	5.1
A-C	21.9	19.82	1.41	18.41	92.9	6.3
C	12.8	13.30	0.64	12.66	95.2	6.7
4Ap	13.9	9.41	0.74	8.67	92.1	6.3
A-C	21.8	17.68	1.20	16.48	93.2	6.3
C	24.6	21.79	0.96	20.83	95.6	6.8
5Ap	15.3	16.11	-	16.11	100+	7.7
A-C	17.9	18.68	-	18.68	100+	7.8
C	20.5	19.78	-	19.78	100+	8.0
6Ap	13.7	9.73	-	9.73	100+	7.4
A-C	12.7	10.52	0.02	10.50	99.8	7.1
C	8.8	8.97	-	8.97	100+	7.6
7Ap	11.4	9.31	0.05	9.26	99.5	7.1
A-C	15.3	15.25	-	15.25	100+	7.6
C	28.6	23.05	-	23.05	100+	7.6
8Ap	12.7	11.18	0.76	10.44	93.4	6.1
A-C	20.5	16.52	0.60	15.92	96.4	7.0
C	20.6	27.63	0.21	27.42	99.2	7.8
9Ap	12.7	13.38	0.60	12.78	95.5	6.6
A-C	23.2	26.25	-	26.25	100+	7.5
C	19.3	26.99	-	26.99	100+	7.8
10Ap	19.2	15.87	2.10	13.77	86.8	5.9
A-C	24.5	20.64	1.21	19.43	94.1	6.3
C	23.5	22.20	1.02	21.18	95.4	6.7

(Continued)

Table 10.-(Continued) Clay content, exchange properties, and pH of the Commerce group soils.

Loc. No. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./ 100g	m.e./ 100g	m.e./ 100g	%	
11Ap	14.0	13.77	1.49	12.28	89.2	5.9
A-C	27.3	22.55	1.22	21.33	94.6	6.4
C	20.7	20.51	1.11	19.40	94.6	6.9
12Ap	16.6	15.56	0.55	15.01	96.5	7.3
A-C	27.3	24.16	-	24.16	100+	7.7
C	16.7	26.07	-	26.07	100+	8.2
13Ap	11.5	15.27	0.50	14.77	96.7	7.0
A-C	19.5	20.69	-	20.69	100+	7.7
C	26.2	24.15	-	24.15	100+	7.8
14Ap	16.6	18.19	0.65	17.54	96.4	6.8
A-C	19.4	20.67	-	20.67	100+	7.7
C	23.5	23.24	-	23.24	100+	7.8
15Ap	19.3	19.35	-	19.35	100+	7.5
A-C	16.6	18.42	-	18.42	100+	7.9
C	11.5	11.99	-	11.99	100+	7.9
16Ap	22.0	23.04	1.31	21.73	94.3	6.3
A-C	30.2	27.42	0.66	26.76	97.6	7.1
C	26.1	24.92	-	24.92	100+	7.8
17Ap	12.7	14.05	2.53	11.52	82.0	5.2
A-C	23.3	22.37	1.37	21.00	93.9	6.3
C	30.0	25.72	1.17	24.55	95.5	6.6
18Ap	10.1	11.05	0.84	10.21	92.4	6.7
A-C	22.0	20.82	0.65	20.17	96.9	7.3
C	20.7	21.09	0.30	20.79	98.6	7.8
19Ap	19.3	18.68	1.55	17.13	91.7	5.9
A-C	26.9	23.30	1.01	22.29	95.7	6.8
C	26.0	24.39	0.65	23.74	97.3	7.2
20Ap	14.1	15.84	3.10	12.74	80.4	5.4
A-C	18.0	19.74	2.96	16.78	85.0	6.1
C	15.4	19.16	2.16	17.00	88.7	6.6

(Continued)

Table 10.-(Continued) Clay content, exchange properties, and pH of the Commerce group soils.

Loc. No. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./ 100g	m.e./ 100g	m.e./ 100g	%	
21Ap	16.6	17.32	-	17.32	100+	7.7
A-C	28.8	28.56	-	28.56	100+	7.9
C	18.0	24.88	-	24.88	100+	8.1
22Ap	10.1	11.64	1.03	10.63	91.2	6.2
A-C	15.3	16.29	0.45	15.84	97.2	7.3
C	12.8	13.14	-	13.14	100+	7.7
23Ap	11.5	13.74	2.25	11.49	83.6	5.1
A-C	31.5	27.03	1.79	25.24	93.4	6.3
C	27.5	26.24	1.53	24.71	94.2	6.3
24Ap	15.3	18.26	0.64	17.62	96.5	6.5
A-C	30.1	28.08	0.87	27.21	96.9	6.9
C	23.3	23.70	-	23.70	100+	7.5
25Ap	12.7	22.82	-	22.82	100+	8.2
A-C	12.8	23.25	-	23.25	100+	8.2
C	8.9	14.74	-	14.74	100+	8.3
26Ap	14.1	14.36	1.49	12.87	89.6	5.8
A-C	23.3	21.58	-	21.58	100+	7.7
C	18.0	17.91	-	17.91	100+	8.0
27Ap	11.4	16.50	-	16.50	100+	7.6
A-C	15.4	21.10	-	21.10	100+	8.0
C	22.1	29.86	-	29.86	100+	8.0
28Ap	25.5	14.52	1.85	12.67	87.3	5.8
A-C	24.7	20.66	1.01	19.65	95.1	6.7
C	24.6	20.06	0.70	19.36	96.5	7.1

Table 11.-Physical properties of the Mhoon group soils.

Loc. No. and Horizon	Texture[1/]	Depth, Inches	Structure[2/]	Consistency[3/]	Color[4/]
1Ap	sicl	0-8	Granular	Friable	Gr.br.
A-C	sic	9-20	Blocky	Plastic	Gr.mot.br.
C	sic	20-30	Blocky	Plastic	Gr.
2Ap	sicl	0-8	Blocky	Friable	Dr.gr.br.
A-C	sic	10-20	Weak blocky	Sli. plastic	Dr.gr.br.
C	sic	20-30	Weak blocky	Plastic	Gr.mot.br.
3Ap	sil	0-9	Mod. med. granular	Sli. plastic	Dr.br.
A-C	sil	10-16	Mod. med. subang. blocky	Sli. plastic	Gr.mot.dr.br.
C	sil	18-30	Weak subang. blocky	Friable	Gr.mot.dr.br.
4Ap	sicl	0-9	Subang. blocky	Sli. plastic	V.dr.gr.br.
A-C	sicl	11-20	Med. subang. blocky	Sli. plastic	Gr.mot.br.
C	sic	22-30	Weak subang. blocky	Sli. plastic	Gr.mot.br.
5Ap	sicl	0-7	Fine subang. blocky	Friable	V.dr.gr.
A-C	sicl	9-15	Med. subang. blocky	Sli. plastic	V.dr.gr.br.
C	sic	17-30	Weak med. subang. blocky	Sli. plastic	Dr.gr.mot.gr.
6Ap	sil	0-10	Granular	Friable	V.dr.gr.br.
A-C	sic	12-20	Blocky	Plastic	Gr.mot.br.
C	sic	20-30	Blocky	Plastic	Gr.mot.br.

(Continued)

Table 11.-(Continued) Physical properties of the Mhoon group soils.

Loc. No. and Horizon	Texture[1/]	Depth, Inches	Structure[2/]	Consistency[3/]	Color[4/]
7Ap	sicl	0-8	Blocky	Sli. plastic	V.dr.gr.br.
A-C	sicl	9-17	Weak blocky	Sli. plastic	Gr.mot.br.
C	sicl	18-30	Weak blocky	Friable	Gr.mot.br.
8Ap	sil	0-8	Granular	Friable	Dr.gr.
A-C	sil	12-18	Weak blocky	Friable	Dr.gr.
C	sil	24-30	Weak blocky	Friable	Dr.gr.
9Ap	sil	0-10	Granular	Friable	V.dr.br.
A-C	sicl	11-20	Blocky	Sli. plastic	Dr.gr.mot.br.
C	sicl	20-30	Weak blocky	Friable	Dr.gr.mot.br.
10Ap	sil	0-6	Granular	Friable	Dr.gr.br.
A-C	sicl	8-20	Weak blocky	Sli. plastic	Dr.gr.
C	sicl	20-30	Weak blocky	Sli. plastic	Dr.gr.mot.gr.br.
11Ap	sil	0-8	Granular	Friable	V.dr.gr.br.
A-C	sicl	10-20	Weak blocky	Sli. plastic	Gr.mot.br.
C	sicl	20-30	Weak blocky	Sli. plastic	Gr.mot.br.
12Ap	sil	0-10	Granular	Friable	V.dr.gr.br.
A-C	sicl	12-21	Weak blocky	Friable	Gr.mot.br.
C	sic	21-30	Weak blocky	Friable	Gr.mot.br.

(Continued)

Table 11.-(Continued) Physical properties of the Mhoon group soils.

Loc. No. and Horizon	Texture[1]	Depth, Inches	Structure[2]	Consistency[3]	Color[4]
13Ap	sicl	0-9	Granular	Friable	Dr.br.
A-C	sicl	10-20	Weak blocky	Friable	Br.mot.gr.
C	sicl	20-30	Weak blocky	Friable	Gr.mot.br.
14Ap	sicl	0-8	Granular	Sli. plastic	V.dr.gr.br.
A-C	sicl	10-20	Weak blocky	Sli. plastic	Gr.mot.br.
C	sicl	20-30	Weak blocky	Friable	Gr.mot.br.
15Ap	sil	0-8	Granular	Friable	V.dr.gr.br.
A-C	sil	10-23	Weak blocky	Friable	Dr.gr.mot.br.
C	sicl	23-30	Weak blocky	Friable	Dr.gr.
16Ap	sil	0-9	Granular	Friable	V.dr.gr.br.
A-C	sic	10-20	Weak blocky	Sli. plastic	Gr.mot.br.
C	sic	20-30	Weak blocky	Sli. plastic	Gr.mot.br.
17Ap	c	0-9	Fine blocky	Sli. plastic	Dr.gr.
A-C	c	10-20	Weak blocky	Sli. plastic	Gr.
C	c	22-30	Weak blocky	Sli. plastic	Gr.
18Ap	sil	0-7	Granular	Friable	V.dr.gr.br.
A-C	sic	8-20	Blocky	Plastic	Gr.mot.br.
C	sic	20-30	Blocky	Plastic	Gr.mot.br.

(Continued)

Table 11.-(Continued) Physical properties of the Mhoon group soils.

Loc. No. and Horizon	Texture[1/]	Depth, Inches	Structure[2/]	Consistency[3/]	Color[4/]
19Ap	sil	0-9	Granular	Friable	Dr.gr.br.
A-C	sicl	10-20	Weak blocky	Friable	Gr.mot.br.
C	sicl	20-30	Weak blocky	Friable	Gr.mot.br.
20Ap	sil	0-10	Granular	Friable	Dr.gr.br.
A-C	sil	12-20	Weak blocky	Sli. plastic	Dr.gr.dr.gr.br.
C	sil	20-30	Weak blocky	Friable	Dr.gr.dr.gr.br.
21Ap	sicl	0-9	Granular	Friable	V.dr.gr.br.
A-C	sicl	10-16	Weak blocky	Sli. plastic	Gr.mot.br.
C	sil	18-30	Weak blocky	Friable	Gr.mot.br.
22Ap	sicl	0-9	Granular	Friable	V.dr.gr.br.
A-C	sicl	10-20	Weak blocky	Plastic	Gr.mot.br.
C	sic	20-30	Weak blocky	Sli. plastic	Gr.mot.br.
23Ap	sil	0-9	Granular	Friable	V.dr.gr.br.
A-C	sic	10-20	Weak blocky	Sli. plastic	Gr.mot.br.
C	sic	20-30	Weak blocky	Sli. plastic	Gr.mot.br.
24Ap	sicl	0-9	Med. ang. blocky	Sli. plastic	Dr.br.
A-C	sicl	10-14	Ang. blocky	Plastic	V.dr.gr.mot.br.
C	sic	16-30	Weak subang. blocky	Sli. plastic	Gr.mot.br.

(Continued)

Table 11.-(Continued) Physical properties of the Mhoon group soils.

Loc. No. and Horizon	Texture[1/]	Depth, Inches	Structure[2/]	Consistency[3/]	Color[4/]
25Ap	sil	0-10	Strong fine granular	Sli. plastic	V.dr.gr.br.
A-C	sil	11-17	Med. subang. blocky	Sli. plastic	Gr.
C	sil	18-30	Fine subang. blocky	Sli. plastic	Gr.mot.br.
26Ap	sil	0-10	Weak coarse granular	Sli. plastic	V.dr.gr.br.
A-C	sicl	11-20	Med. subang. blocky	Sli. plastic	Gr.mot.br.
C	sicl	20-30	Weak subang. blocky	Friable	Gr.mot.br.
27Ap	sicl	0-8	Granular	Friable	V.dr.gr.br.
A-C	sicl	10-20	Weak blocky	Friable	Gr.mot.br.
C	sicl	20-30	Weak blocky	Sli. plastic	Gr.mot.br.
28Ap	sil	0-9	Granular	Friable	V.dr.br.
A-C	sil	10-20	Blocky	Sli. plastic	V.dr.gr.br.
C	sicl	20-30	Weak blocky	Sli. plastic	Gr.mot.br.
29Ap	sicl	0-9	Granular	Friable	V.dr.gr.br.
A-C	sic	10-20	Weak blocky	Plastic	Gr.mot.br.
C	sicl	20-30	Weak blocky	Friable	Br.mot.gr.
30Ap	sil	0-9	Strong med. granular	Sli. plastic	Dr.gr.br.
A-C	sicl	10-20	Weak subang. blocky	Sli. plastic	Dr.gr.mot.gr.
C	sil	20-30	Weak subang. blocky	Sli. plastic	Dr.gr.mot.gr.

[1/] sil = silt loam; sicl = silty clay loam; sic = silty clay; c = clay.

[2/] mod. = moderately; med. = medium; subang. = subangular.

[3/] sli. = slightly.

[4/] v. = very; dr. = dark; gr. = gray, grayish; br. = brown; mot. = mottled.

Table 12.-Potassium and sodium contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
1Ap	420	588	1.88	97	26	1.20
A-C	257	356	2.04	119	37	1.08
C	236	337	2.16	120	46	1.00
2Ap	289	380	1.94	97	32	1.20
A-C	243	332	1.96	122	35	1.10
C	255	372	2.00	113	43	1.00
3Ap	207	235	1.92	61	151	1.28
A-C	161	191	1.92	87	166	1.32
C	154	144	1.80	86	153	1.52
4A	325	367	1.80	63	215	1.24
A-C	216	258	1.76	82	218	1.20
C	232	278	1.80	93	233	1.44
5Ap	271	319	1.80	76	199	1.28
A-C	282	311	1.92	62	192	1.24
C	300	319	1.80	90	272	1.04
6Ap	158	179	1.80	63	27	1.36
A+C	260	279	2.00	108	61	1.20
C	198	384	2.08	126	92	1.22
7Ap	266	341	1.72	76	39	1.36
A-C	247	313	1.72	90	49	1.36
C	268	314	1.68	109	73	1.28
8Ap	195	205	1.95	50	23	1.66
A-C	154	143	2.02	71	32	1.76
C	217	199	1.90	72	34	1.49
9Ap	196	272	1.88	66	45	1.36
A-C	264	342	1.84	89	58	1.26
C	243	315	2.02	108	70	1.24
10Ap	124	144	2.14	55	36	1.82
A-C	253	305	2.37	99	79	1.50
C	231	285	2.27	92	78	1.50

(Continued)

Table 12.-(Continued) Potassium and sodium contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
11Ap	315	397	1.90	53	22	1.36
A-C	279	369	1.90	63	42	1.38
C	275	370	1.90	93	59	1.28
12Ap	176	217	1.68	77	39	1.28
A-C	240	256	1.70	90	53	1.36
C	316	412	1.74	131	77	1.16
13Ap	161	218	1.80	97	34	1.18
A-C	167	238	1.96	119	48	1.18
C	180	296	1.96	142	59	1.00
14Ap	245	338	1.66	56	27	1.26
A-C	253	369	1.72	74	46	1.16
C	232	314	1.70	89	56	1.16
15Ap	123	198	1.80	78	41	1.16
A-C	124	200	1.80	95	65	1.16
C	140	218	1.72	85	56	0.96
16Ap	123	162	1.72	92	48	1.46
A-C	220	395	1.94	176	78	1.20
C	213	373	1.96	164	101	1.22
17Ap	383	484	1.92	74	37	1.27
A-C	322	432	1.88	149	100	1.22
C	253	285	1.97	129	96	1.25
18Ap	187	291	1.76	100	41	1.40
A-C	214	355	1.88	148	94	1.22
C	238	442	1.92	186	121	1.08
19Ap	155	236	1.80	95	40	1.40
A-C	157	239	1.84	126	55	1.28
C	169	277	1.84	138	64	1.24
20Ap	122	133	1.89	71	40	1.44
A-C	165	172	1.76	146	120	1.50
C	186	163	1.89	153	111	1.47

(Continued)

Table 12.-(Continued) Potassium and sodium contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
21Ap	218	255	1.66	63	38	1.18
A-C	193	228	1.68	88	48	1.24
C	187	219	1.66	100	58	1.24
22Ap	240	274	1.96	61	33	1.24
A-C	189	221	1.96	86	59	1.24
C	239	288	2.00	110	74	1.16
23Ap	197	209	1.80	72	44	1.32
A-C	211	259	1.96	103	81	1.24
C	232	258	1.94	108	79	1.28
24Ap	177	201	1.88	78	44	1.20
A-C	163	183	2.08	86	56	1.30
C	240	281	2.12	156	114	1.24
25Ap	93	108	1.76	64	139	1.54
A-C	150	144	1.79	82	156	1.66
C	165	144	1.87	95	152	1.57
26Ap	145	145	1.84	70	41	1.48
A-C	200	204	2.08	107	78	1.44
C	177	183	1.88	106	75	1.52
27Ap	187	218	1.88	75	31	1.34
A-C	237	258	2.08	95	49	1.28
C	234	285	2.00	94	52	1.22
28Ap	123	127	1.86	64	40	1.32
A-C	160	145	1.84	81	41	1.30
C	203	237	2.08	82	49	1.30
29Ap	188	238	1.88	67	44	1.24
A-C	239	297	1.98	105	79	1.26
C	182	219	1.98	99	75	1.16
30Ap	124	163	1.87	246	249	1.54
A-C	187	220	1.74	168	141	1.54
C	166	181	1.76	168	139	1.54

Table 13.-Calcium and magnesium contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
1Ap	2926	3622	0.57	745	882	0.60
A-C	4892	5115	0.74	1445	1181	0.90
C	4597	5497	0.74	1147	1050	0.91
2Ap	2791	3193	0.67	796	877	0.66
A-C	6431	5535	0.88	1898	1015	0.93
C	5523	5829	0.77	1468	1070	0.90
3Ap	2190	2685	0.92	413	561	0.53
A-C	2444	2999	0.92	653	671	0.63
C	3311	2740	1.12	1100	629	0.63
4Ap	3334	3798	0.92	734	807	0.69
A-C	3226	3635	0.92	864	968	0.76
C	3504	4433	1.08	939	1044	0.90
5Ap	3043	3703	0.92	740	858	0.68
A-C	2964	3562	0.92	814	887	0.72
C	4516	5768	1.12	1134	1161	0.92
6Ap	3167	2200	0.76	1134	527	0.47
A-C	3921	4680	0.70	964	917	0.70
C	4480	5675	0.74	1157	1116	0.80
7Ap	2733	3315	0.54	625	663	0.59
A-C	3079	3807	0.70	746	735	0.67
C	3326	4205	0.76	821	801	0.75
8Ap	2468	3240	0.99	512	437	0.46
A-C	3961	2642	1.47	1197	447	0.58
C	4395	3250	1.41	1310	552	0.60
9Ap	2275	2660	0.69	538	543	0.49
A-C	3440	3970	0.69	844	849	0.73
C	3486	4014	0.70	940	924	0.79
10Ap	2206	2886	0.99	422	361	0.41
A-C	3481	4641	1.08	970	912	0.77
C	3403	4264	0.86	893	931	0.70

(Continued)

Table 13.-(Continued) Calcium and magnesium contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
11Ap	2397	2659	0.70	496	497	0.49
A-C	3222	3922	0.75	811	774	0.68
C	3412	4014	0.74	929	897	0.71
12Ap	2382	2447	0.71	476	507	0.52
A-C	3056	3377	0.80	793	676	0.64
C	4420	5150	0.78	1253	1162	0.88
13Ap	2548	2946	0.57	549	689	0.52
A-C	3023	3695	0.63	667	784	0.58
C	5187	4880	0.73	1521	1109	0.87
14Ap	3526	3739	0.74	970	822	0.69
A-C	4218	4743	0.77	981	905	0.80
C	3941	4426	0.80	1001	848	0.81
15Ap	2362	2732	0.54	637	647	0.48
A-C	2465	3081	0.57	665	743	0.58
C	2349	3092	0.51	644	764	0.61
16Ap	1738	2214	0.64	421	432	0.39
A-C	3849	5055	0.71	1072	1051	0.83
C	3622	4650	0.71	1044	1007	0.83
17Ap	3784	4799	0.85	1116	1169	0.72
A-C	4310	5498	0.99	1211	1360	1.06
C	3329	4156	0.90	948	1023	0.66
18Ap	2275	2819	0.60	665	601	0.51
A-C	3629	4708	0.70	929	916	0.76
C	4281	5704	0.70	1103	1079	0.79
19Ap	1963	2613	0.61	485	533	0.45
A-C	2616	3534	0.72	774	742	0.57
C	3035	3872	0.71	927	793	0.66
20Ap	2190	2806	0.95	520	356	0.39
A-C	3267	3392	0.90	796	567	0.54
C	4384	3430	1.12	1176	578	0.58

(Continued)

Table 13.-(Continued) Calcium and magnesium contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
21Ap	3012	2981	0.67	623	637	0.57
A-C	2755	3178	0.64	699	731	0.59
C	3103	3116	0.77	1073	838	0.72
22Ap	2397	3022	0.52	646	738	0.56
A-C	2774	3439	0.54	883	883	0.60
C	3226	4086	0.56	1157	1142	0.72
23Ap	2616	3081	0.63	571	600	0.52
A-C	3357	4223	0.66	940	943	0.78
C	3333	4219	0.63	939	902	0.76
24Ap	3274	3887	0.72	646	766	0.58
A-C	3397	4073	0.68	860	877	0.63
C	3802	4580	1.04	1196	1252	1.05
25Ap	2060	2456	1.09	515	487	0.50
A-C	2517	2799	1.22	660	631	0.52
C	4186	2707	1.24	1588	703	0.70
26Ap	2384	2811	0.59	560	672	0.51
A-C	3207	3932	0.60	981	942	0.70
C	2590	3053	0.66	804	836	0.51
27Ap	2577	2888	0.58	738	691	0.56
A-C	3557	3850	0.68	1263	995	0.76
C	3571	4000	0.65	1190	1004	0.83
28Ap	2222	2842	0.64	514	487	0.44
A-C	4449	3000	0.89	1759	760	0.71
C	3050	3880	0.66	999	1002	0.75
29Ap	2420	2894	0.47	772	812	0.66
A-C	3187	4180	0.54	1211	1116	0.74
C	2354	3032	0.53	792	319	0.72
30Ap	2905	3750	0.96	515	487	0.58
A-C	3249	4218	0.98	975	877	0.61
C	4179	2877	1.18	1358	753	0.64

Table 14.-Phosphorus, sulphur, carbon and nitrogen contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic Matter	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	%	
1Ap	376	719	12	2.76	1.60	0.162	9.9
A-C	259	562	8	1.26	0.73	0.097	7.5
C	257	540	8	1.19	0.69	0.091	7.6
2Ap	358	640	10	2.31	1.34	0.127	10.6
A-C	242	531	8	1.28	0.74	0.080	9.2
C	248	570	4	1.14	0.66	0.081	8.1
3Ap	342	643	8	1.50	0.87	0.101	8.6
A-C	273	466	18	0.83	0.48	0.061	7.9
C	321	417	16	0.43	0.25	0.042	5.9
4Ap	280	704	8	2.78	1.61	0.158	10.2
A-C	198	489	6	1.09	0.63	0.075	8.4
C	261	537	6	1.05	0.61	0.074	8.2
5Ap	345	671	12	1.86	1.08	0.109	9.9
A-C	330	673	8	2.05	1.19	0.116	10.3
C	140	444	10	1.40	0.81	0.100	8.1
6Ap	329	461	12	1.41	0.82	0.075	10.9
A-C	201	527	6	1.24	0.72	0.080	9.0
C	234	452	8	0.93	0.54	0.061	8.8
7Ap	216	508	16	1.88	1.09	0.111	9.8
A-C	225	449	8	1.34	0.78	0.084	9.3
C	276	467	4	0.79	0.46	0.058	7.9
8Ap	270	410	6	1.21	0.70	0.066	10.6
A-C	290	415	6	0.47	0.27	0.032	8.4
C	318	440	6	0.57	0.33	0.036	9.2
9Ap	284	606	12	1.86	1.08	0.105	10.3
A-C	240	564	6	1.45	0.84	0.088	9.5
C	244	512	6	0.95	0.55	0.062	8.9
10Ap	221	354	6	1.03	0.60	0.059	10.2
A-C	204	517	4	0.91	0.53	0.063	8.4
C	310	690	6	0.43	0.25	0.050	5.0

(Continued)

Table 14.-(Continued) Phosphorus, sulphur, carbon and nitrogen contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic Matter	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	%	
11Ap	212	619	10	2.10	1.22	0.113	10.8
A-C	200	462	6	1.38	0.80	0.082	9.7
C	300	584	8	0.95	0.55	0.059	9.3
12Ap	241	526	4	1.79	1.04	0.105	9.9
A-C	263	469	6	1.03	0.60	0.073	8.2
C	270	496	6	0.93	0.54	0.072	7.5
13Ap	235	550	10	1.83	1.06	0.109	9.7
A-C	254	504	6	1.03	0.60	0.079	7.6
C	273	553	6	0.84	0.49	0.068	7.2
14Ap	238	602	6	1.62	0.94	0.102	9.2
A-C	269	609	6	0.98	0.57	0.067	8.5
C	283	628	6	1.57	0.91	0.097	9.4
15Ap	225	481	12	2.05	1.19	0.118	10.1
A-C	183	457	8	1.10	0.64	0.080	8.0
C	156	249	6	0.64	0.37	0.059	6.3
16Ap	242	394	10	1.41	0.82	0.082	10.0
A-C	255	488	4	0.93	0.54	0.078	6.9
C	278	547	4	0.81	0.47	0.059	8.0
17Ap	143	526	6	2.31	1.34	0.135	9.9
A-C	142	493	6	1.40	0.81	0.101	8.0
C	140	383	4	0.72	0.42	0.056	7.5
18Ap	283	485	8	1.86	1.08	0.110	9.8
A-C	190	489	8	1.33	0.77	0.098	7.8
C	173	427	6	1.12	0.65	0.090	7.2
19Ap	219	484	10	1.67	0.97	0.102	9.5
A-C	228	509	8	1.05	0.61	0.069	8.8
C	289	575	6	0.88	0.51	0.066	7.7
20Ap	236	344	8	0.74	0.43	0.049	8.8
A-C	243	465	4	0.60	0.35	0.043	8.1
C	287	510	4	0.55	0.32	0.046	6.9

(Continued)

Table 14.-(Continued) Phosphorus, sulphur, carbon and nitrogen contents of the Mhoon group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic Matter	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	%	
21Ap	195	446	6	1.69	0.98	0.096	10.2
A-C	195	465	4	1.52	0.88	0.089	9.9
C	312	537	4	0.76	0.44	0.058	7.5
22Ap	233	662	6	2.26	1.31	0.123	10.6
A-C	235	592	4	1.22	0.71	0.073	9.7
C	249	646	4	0.88	0.51	0.058	8.8
23Ap	320	651	6	1.86	1.08	0.090	12.0
A-C	249	561	4	0.88	0.51	0.053	9.6
C	253	565	4	0.91	0.53	0.051	10.4
24Ap	521	999	10	2.26	1.31	0.204	6.4
A-C	402	867	4	1.95	1.13	0.121	9.3
C	251	615	4	0.91	0.53	0.072	7.4
25Ap	223	481	8	1.53	0.89	0.098	9.1
A-C	258	484	4	0.93	0.54	0.061	8.8
C	304	520	4	0.57	0.33	0.040	8.2
26Ap	212	484	8	1.67	0.97	0.112	8.7
A-C	240	421	4	1.12	0.65	0.075	8.7
C	319	509	4	0.50	0.29	0.037	7.8
27Ap	258	600	6	1.83	1.06	0.096	11.0
A-C	326	587	6	1.02	0.59	0.059	10.0
C	372	677	4	0.95	0.55	0.063	8.7
28Ap	282	663	6	1.81	1.05	0.093	11.3
A-C	310	526	4	0.60	0.35	0.032	10.9
C	271	528	2	0.72	0.42	0.044	9.5
29Ap	166	505	6	1.90	1.10	0.106	10.4
A-C	174	522	4	1.02	0.59	0.070	8.4
C	240	505	4	0.69	0.40	0.043	9.3
30Ap	281	528	8	1.45	0.84	0.136	6.2
A-C	272	538	4	0.83	0.48	0.065	7.4
C	294	490	4	0.46	0.27	0.040	6.7

Table 15.-Clay content, exchange properties, and pH value of the Mhǫon group soils.

Loc. No. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./ 100g	m.e./ 100g	m.e./ 100g	%	
1Ap	34.1	29.02	1.94	27.08	93.31	6.4
A-C	46.4	36.58	0.09	36.49	99.75	7.5
C	47.9	37.69	0.40	37.29	98.94	7.6
2Ap	27.1	25.09	0.71	24.38	97.17	7.1
A-C	44.4	37.13	----	37.13	100+	7.7
C	50.5	39.20	----	39.20	100+	7.7
3Ap	24.6	22.30	2.95	19.35	86.77	5.9
A-C	24.7	22.60	0.80	21.80	96.46	6.5
C	16.8	20.12	0.15	19.97	99.25	7.2
4Ap	36.8	31.10	3.52	27.58	88.68	6.0
A-C	38.3	29.19	1.33	27.86	95.44	6.6
C	41.3	33.71	1.13	32.58	96.65	6.7
5Ap	32.8	29.93	0.86	27.35	91.38	6.0
A-C	34.3	29.25	0.83	26.83	91.73	6.2
C	52.7	41.08	1.18	40.51	91.61	6.8
6Ap	11.5	16.00	0.03	15.97	99.81	7.6
A-C	42.4	32.15	0.14	32.01	99.56	7.7
C	53.6	39.05	----	39.05	100+	7.6
7Ap	34.6	26.75	3.62	23.13	86.47	5.6
A-C	36.8	28.05	1.88	26.17	93.30	6.5
C	36.8	29.60	0.78	28.82	97.36	7.1
8Ap	19.4	20.70	0.23	20.47	98.89	6.9
A-C	14.2	17.44	----	17.44	100+	7.0
C	20.6	21.51	----	21.51	100+	7.0
9Ap	25.9	21.25	2.53	18.72	88.09	5.9
A-C	39.6	29.50	1.45	28.05	95.08	6.9
C	39.6	29.52	0.64	28.88	97.83	7.4
10Ap	14.1	19.75	1.78	17.97	90.99	6.9
A-C	41.0	34.24	2.31	31.93	93.25	6.7
C	34.1	31.57	1.42	30.15	95.50	7.0

(Continued)

Table 15.-(Continued) Clay content, exchange properties, and pH value of the Mhoon group soils.

Loc. No. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./ 100g	m.e./ 100g	m.e./ 100g	%	
11Ap	24.5	20.31	1.76	18.55	91.33	6.2
A-C	38.2	28.48	1.09	27.39	96.17	6.8
C	39.6	29.32	0.57	28.75	98.06	7.2
12Ap	23.3	20.53	3.34	17.19	83.73	5.8
A-C	27.4	24.06	0.69	23.37	97.13	7.0
C	48.0	37.17	0.35	36.82	99.06	7.3
13Ap	28.5	23.18	2.00	19.38	91.37	6.3
A-C	28.7	26.41	0.59	25.82	97.76	7.1
C	37.0	34.66	----	34.66	100+	7.7
14Ap	30.0	26.71	0.17	26.54	99.36	7.5
A-C	39.5	32.74	0.33	32.41	98.99	7.5
C	36.9	30.45	0.21	30.24	99.31	7.6
15Ap	20.5	21.21	1.47	19.74	93.07	6.5
A-C	25.9	23.03	0.65	22.38	91.18	7.2
C	32.5	23.19	0.56	22.63	97.58	7.1
16Ap	15.4	16.29	0.99	15.30	93.92	6.6
A-C	48.0	36.13	0.74	35.39	97.95	7.5
C	47.7	33.70	0.66	33.04	98.04	7.4
17Ap	56.6	37.05	1.91	35.14	94.87	6.3
A-C	66.7	41.56	1.19	40.37	97.14	6.4
C	49.4	31.12	0.66	30.46	97.88	6.5
18Ap	22.1	21.43	1.40	20.03	93.47	6.4
A-C	45.4	33.80	1.31	32.49	96.12	6.7
C	57.9	40.03	0.86	39.17	97.85	7.0
19Ap	23.2	20.68	2.40	18.28	88.39	5.9
A-C	28.8	25.61	0.91	24.70	96.45	6.9
C	33.0	28.23	1.27	26.96	95.50	7.2
20Ap	12.8	17.51	----	17.51	100+	7.3
A-C	23.4	22.65	----	22.65	100+	7.3
C	22.0	22.87	----	22.87	100+	7.4

(Continued)

Table 15.-(Continued) Clay content, exchange properties, and pH value of the Mhoon group soils.

Loc. No. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./ 100g	m.e./ 100g	m.e./ 100g	%	
21Ap	27.3	23.22	2.20	21.02	90.52	6.2
A-C	30.0	24.90	2.13	22.77	91.44	6.3
C	26.0	23.62	0.25	23.37	98.94	7.6
22Ap	30.0	26.14	4.40	22.10	84.54	5.8
A-C	34.1	27.43	2.04	25.39	92.56	6.5
C	43.8	32.71	1.70	31.01	94.80	6.8
23Ap	24.6	23.38	2.24	21.14	90.42	6.2
A-C	40.9	30.32	0.33	29.99	98.91	6.9
C	40.9	29.89	0.28	29.61	99.06	7.2
24Ap	35.2	28.13	1.62	26.51	94.24	6.1
A-C	39.3	30.14	1.76	28.38	94.16	6.4
C	48.1	34.77	0.23	34.54	99.34	6.8
25Ap	18.1	21.37	4.15	17.22	80.58	5.3
A-C	16.9	20.98	0.68	20.30	96.76	7.1
C	15.5	20.43	----	20.43	100+	7.6
26Ap	23.4	22.29	2.08	20.21	90.67	5.5
A-C	37.0	28.82	0.45	28.37	98.44	6.6
C	28.8	23.03	----	23.03	100+	6.8
27Ap	29.9	23.00	2.11	20.89	90.83	6.4
A-C	36.8	28.58	0.17	28.41	99.40	7.0
C	38.5	29.62	0.29	29.33	99.02	7.3
28Ap	19.3	19.80	1.03	18.77	94.80	6.8
A-C	23.3	21.88	----	21.88	100+	7.3
C	39.0	29.00	0.43	28.57	98.52	7.3
29Ap	35.2	25.70	3.66	22.04	85.76	5.6
A-C	46.6	32.86	1.56	31.30	95.25	6.3
C	32.6	19.82	1.11	18.71	94.40	6.4
30Ap	19.4	25.48	1.12	24.36	95.60	7.2
A-C	30.5	30.71	1.14	29.57	96.29	7.1
C	23.6	22.50	0.77	21.73	96.58	7.5

Table 16.-Physical properties of the Sharkey group soils.

Loc. No. and Horizon	Texture	Depth Inches	Structure	Consistency	Color
1Ap	c	0-9	Weak blocky	Plastic	V.dr.gr.
A-C	c	11-18	Blocky	Plastic	Dr.gr.mot.br.
C	c	20-26	Blocky	Plastic	Dr.gr.gr.
2Ap	sic	0-4	Weak blocky	Plastic	V.dr.gr.br.
A-C	c	6-20	Strong blocky	Plastic	Dr.gr.mot.w/br.
C	c	22-26	Strong blocky	Plastic	Dr.gr.mot.br.
3Ap	c	0-8	Weak blocky	Plastic	V.dr.gr.br.
A-C	c	10-18	Blocky	Plastic	V.dr.gr.mot.w/br.
C	c	20-26	Strong blocky	Plastic	Dr.gr.mot.br.
4Ap	c	0-7	Weak blocky	Plastic	Dr.gr.
A-C	c	9-18	Blocky	Plastic	Dr.gr.mot.gr.
C	c	20-26	Strong blocky	Plastic	Dr.gr.mot.gr.br.
5Ap	sic	0-9	Weak granular	Plastic	V.dr.gr.br.
A-C	sic	11-19	Blocky	Plastic	Dr.gr.mot.br.
C	sic	21-26	Blocky	Plastic	Dr.gr.mot.br.
6Ap	c	0-9	Weak blocky	Plastic	V.dr.gr.
A-C	c	11-18	Blocky	Plastic	Dr.gr.mot.gr.&br.
C	c	20-26	Blocky	Plastic	Gr.mot.dr.gr.&br.
7Ap	c	0-7	Weak blocky	Plastic	V.dr.gr.
A-C	c	9-16	Blocky	Plastic	Dr.gr.mot.v.dr.gr.
C	c	18-26	Strong blocky	Plastic	Dr.gr.mot.br.
8Ap	c	0-8	Blocky	Plastic	V.dr.gr.br.
A-C	c	10-18	Blocky	Plastic	V.dr.gr.mot.gr.br.
C	c	20-26	Blocky	Plastic	Dr.gr.mot.gr.&br.
9Ap	c	0-10	Weak blocky	Plastic	V.dr.gr.
A-C	c	12-19	Blocky	Plastic	Dr.gr.mot.gr.
C	c	21-26	Strong blocky	Plastic	Gr.dr.gr.mot.gr.
10Ap	c	0-9	Weak blocky	Plastic	V.dr.gr.
A-C	c	11-18	Blocky	Plastic	Dr.gr.
C	c	20-26	Blocky	Plastic	Dr.gr.mot.gr.
11Ap	c	0-7	Weak blocky	Plastic	V.dr.gr.
A-C	c	9-18	Moderate blocky	Plastic	V.dr.gr.mot.dr.gr.
C	c	20-26	Strong blocky	Plastic	Dr.gr.mot.gr.br.
12Ap	sicl	0-9	Weak blocky	Plastic	Dr.gr.br.
A-C	sic	11-18	Blocky	Plastic	Dr.gr.
C	sic	20-26	Blocky	Plastic	Gr.mot.dr.gr.&br.

(Continued)

Table 16.-(Continued) Physical properties of the Sharkey group soils.

Loc. No. and Horizon	Texture	Depth Inches	Structure	Consistency	Color
13Ap	c	0-8	Weak blocky	Plastic	V.dr.gr.&br.
A-C	c	10-18	Blocky	Plastic	V.dr.gr.mot.gr.
C	c	20-26	Blocky	Plastic	L.gr.mot.dr.gr.
14Ap	c	0-8	Weak blocky	Plastic	V.dr.gr.br.
A-C	c	10-16	Blocky	Plastic	Dr.gr.mot.br.
C	c	18-26	Blocky	Plastic	V.dr.gr.mot.br.
15Ap	c	0-8	Weak blocky	Plastic	V.dr.gr.&br.
A-C	c	10-18	Blocky	Plastic	Dr.gr.mot.br.
C	c	20-26	Blocky	Plastic	Dr.gr.mot.br.
16Ap	c	0-10	Fine blocky, Weak platy	Plastic	V.dr.gr.br.
A-C	c	12-18	Blocky	Plastic	Dr.gr.mot.br.
C	c	20-26	Blocky	Plastic	Dr.gr.mot.br.
17Ap	c	0-8	Weak blocky	Plastic	V.dr.gr.
A-C	c	10-18	Blocky	Plastic	Dr.gr.mot.br.
C	c	20-26	Blocky	Plastic	Gr.mot.dr.gr.&br.
18Ap	c	0-9	Weak blocky	Plastic	V.dr.gr.
A-C	c	11-19	Blocky	Plastic	Dr.gr.mot.br.
C	c	21-26	Blocky	Plastic	Dr.gr.mot.gr.&br.
19Ap	c	0-9	Weak blocky	Plastic	V.dr.gr.
A-C	c	11-19	Blocky	Plastic	Gr.mot.dr.gr.&br.
C	c	21-26	Blocky	Plastic	Gr.mot.dr.gr.
20Ap	sicl	0-7	Strong blocky	Plastic	V.dr.gr.
A-C	sicl	8-16	Blocky	Plastic	V.dr.gr.
C	sic	17-30	Blocky	Plastic	Gr.mot.v.dr.gr.br.
21Ap	c	0-12	Weak blocky	Plastic	Dr.gr.
A-C	c	14-20	Blocky	Plastic	Dr.gr.mot.gr.&br.
C	c	22-28	Blocky	Plastic	Dr.gr.mot.gr.&br.
22Ap	c	0-10	Blocky	Plastic	V.dr.gr.br.
A-C	c	12-19	Blocky	Plastic	Dr.gr.mot.br.
C	sic	21-26	Blocky	Plastic	Dr.gr.
23Ap	sic	0-9	Weak blocky	Plastic	V.dr.gr.&br.
A-C	sic	11-19	Blocky	Plastic	V.dr.gr.&br.
C	sic	21-26	Blocky	Plastic	Dr.gr.mot.br.&gr.
24Ap	sicl	0-8	Weak blocky	Plastic	V.dr.gr.br.
A-C	c	10-18	Blocky	Plastic	Dr.gr.mot.gr.&br.
C	c	20-26	Blocky	Plastic	Gr.mot.gr.&br, mot.red

1/sicl = silty clay loam; sic = silty clay; c = clay.

2/v = very; dr = dark; gr. = gray, grayish; br. = brown; mot. = mottled; w/br.= with brown; L. = light.

Table 17.-Potassium and sodium contents of the Sharkey group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
1Ap	367	528	1.57	82	54	0.99
A-C	277	488	1.55	102	68	0.97
C	241	437	1.96	124	71	1.11
2Ap	242	496	1.56	85	68	1.07
A-C	256	439	1.50	149	80	1.05
C	277	460	1.50	173	101	1.27
3Ap	212	370	1.52	161	98	1.19
A-C	218	389	1.50	109	90	1.20
C	232	433	1.67	124	99	1.19
4Ap	226	400	1.48	103	59	1.13
A-C	270	430	1.51	126	70	1.18
C	273	452	1.54	142	108	1.21
5Ap	339	485	1.63	103	48	1.18
A-C	210	368	1.57	149	70	1.34
C	229	399	1.60	195	132	1.26
6Ap	323	499	1.49	110	148	1.04
A-C	284	478	1.62	147	158	1.16
C	288	471	1.59	163	162	1.18
7Ap	248	392	1.71	124	60	1.07
A-C	236	374	1.63	137	79	1.14
C	220	364	1.70	146	89	1.15
8Ap	280	419	1.67	107	224	1.03
A-C	270	418	1.66	125	188	1.07
C	258	377	1.75	125	200	1.22
9Ap	229	338	1.47	103	110	1.07
A-C	258	405	1.46	136	130	0.93
C	192	312	1.40	137	138	1.13
10Ap	237	332	1.44	111	74	0.98
A-C	227	344	1.47	141	101	1.06
C	233	343	1.56	164	111	0.95
11Ap	261	362	1.45	80	39	1.04
A-C	253	328	1.47	124	51	1.06
C	254	355	1.48	129	78	1.09
12Ap	219	320	1.48	72	68	1.09
A-C	240	324	1.46	120	91	1.13
C	201	285	1.48	124	98	1.21

(Continued)

Table 17.-(Continued) Potassium and sodium contents of the Sharkey group soils.

Loc. No. and Horizon	Extract. K	Exch. K	Total K	Extract. Na	Exch. Na	Total Na
	ppm	ppm	%	ppm	ppm	%
13Ap	248	334	1.98	99	150	1.18
A-C	234	345	1.93	125	164	1.15
C	254	369	1.96	156	181	1.10
14Ap	230	235	1.89	124	58	1.00
A-C	208	324	1.95	195	69	1.07
C	239	327	1.94	244	107	1.07
15Ap	219	299	1.93	106	80	1.18
A-C	233	333	1.94	174	91	1.12
C	234	309	1.97	189	98	1.17
16Ap	301	396	1.86	103	54	1.04
A-C	261	372	1.95	171	70	1.14
C	256	355	1.94	174	93	1.08
17Ap	289	385	1.95	86	70	1.06
A-C	208	308	1.99	154	83	1.17
C	205	304	2.04	185	82	1.23
18Ap	206	292	1.88	146	48	1.11
A-C	186	304	1.91	225	88	1.15
C	221	322	1.98	281	118	1.18
19Ap	215	299	1.89	109	61	1.11
A-C	225	315	1.97	157	98	1.15
C	275	385	1.99	205	117	1.25
20Ap	186	216	1.91	66	48	1.36
A-C	158	173	1.92	72	78	1.36
C	206	223	1.93	134	105	1.17
21Ap	255	336	1.97	94	148	1.25
A-C	256	333	1.99	137	167	1.25
C	248	321	1.97	128	171	1.32
22Ap	222	273	2.04	98	39	1.34
A-C	226	308	1.96	143	70	1.32
C	215	285	2.01	137	74	1.34
23Ap	186	261	1.96	102	59	1.15
A-C	214	288	1.98	127	64	1.25
C	223	311	2.05	132	84	1.32
24Ap	172	241	1.92	94	62	1.47
A-C	215	355	1.92	186	82	1.29
C	230	382	2.05	200	94	1.36

Table 18.-Calcium and magnesium contents of the Sharkey group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
1Ap	5244	6451	0.73	903	934	0.70
A-C	5590	6990	0.73	1065	1145	0.80
C	5294	6668	1.84	1108	1063	0.86
2Ap	4107	5390	0.61	909	896	0.70
A-C	5298	7078	0.67	1094	1274	0.86
C	5679	6626	1.17	1290	1280	1.00
3Ap	3768	5085	1.05	797	966	0.77
A-C	3749	5010	0.99	970	1072	0.77
C	4223	5650	0.97	1229	1347	1.02
4Ap	4687	5846	0.80	984	1097	0.88
A-C	4907	6160	1.12	1236	1246	1.04
C	4882	6193	1.05	1169	1188	1.01
5Ap	4062	5737	0.80	975	992	0.88
A-C	3990	6140	1.11	1083	1118	0.91
C	4169	6413	1.11	1185	1251	0.98
6Ap	5425	7508	1.10	1061	1189	0.99
A-C	6342	8071	1.43	1347	1219	1.10
C	6525	8116	1.24	1504	1147	1.10
7Ap	5655	6863	0.93	1217	1407	1.03
A-C	5109	6587	0.93	1227	1435	1.01
C	5436	6533	0.99	1402	1514	1.07
8Ap	5088	6488	1.05	1103	1247	0.97
A-C	5144	6634	1.11	1095	1263	1.00
C	4882	6543	1.11	1059	1138	0.98
9Ap	3957	4881	0.74	1016	1201	0.83
A-C	4418	5642	0.80	1267	1538	1.00
C	3635	4851	0.80	1039	1214	0.78
10Ap	5339	6552	1.05	1117	1266	0.90
A-C	5352	6078	1.10	1138	1326	0.91
C	5409	6560	0.75	1217	1361	0.98
11Ap	4775	5588	0.61	1109	1221	0.88
A-C	5803	6492	0.81	1379	1301	1.04
C	6653	6792	1.05	1269	1359	1.00
12Ap	4569	1301	0.74	803	988	0.71
A-C	4964	5475	0.68	980	1050	0.88
C	4037	5056	0.81	933	845	0.87

(Continued)

Table 18.-(Continued) Calcium and magnesium contents of the Sharkey group soils.

Loc. No. and Horizon	Extract. Ca	Exch. Ca	Total Ca	Extract. Mg	Exch. Mg	Total Mg
	ppm	ppm	%	ppm	ppm	%
13Ap	6495	7397	1.36	1307	1295	0.85
A-C	5348	6634	1.11	1326	1528	0.79
C	5005	6298	1.17	1385	1628	0.88
14Ap	5504	6677	1.04	1239	1394	0.81
A-C	5656	6724	1.29	1339	1445	0.89
C	6570	9401	1.84	1899	1479	0.94
15Ap	4508	5508	0.79	1154	1292	0.77
A-C	4939	5804	1.41	1291	1427	0.87
C	4764	5469	1.35	1241	1341	0.83
16Ap	4954	4950	1.17	1190	1395	0.78
A-C	5425	5950	1.49	1428	1548	0.96
C	6340	6038	1.60	1615	1513	0.92
17Ap	3968	4771	0.98	1078	1247	0.75
A-C	4246	5385	1.11	1221	1381	0.82
C	4299	5452	1.37	1236	1409	0.80
18Ap	4985	5948	1.17	1313	1598	0.83
A-C	5015	5834	1.17	1389	1610	0.88
C	4850	5924	1.18	1376	1551	0.93
19Ap	5761	6392	1.17	1068	1191	0.77
A-C	6480	6655	1.45	1549	1353	0.88
C	6565	7400	1.84	1514	1724	0.90
20Ap	3973	4492	1.17	924	943	0.61
A-C	4566	4791	1.36	1020	960	0.62
C	3823	5127	1.60	1770	1080	0.90
21Ap	4953	6035	1.13	1307	1499	0.80
A-C	4794	6098	1.20	1362	1534	0.85
C	4503	5644	1.13	1291	1455	0.86
22Ap	4943	5712	1.38	1114	1153	0.73
A-C	4676	5938	1.13	1282	1384	0.83
C	4199	5140	1.12	1245	1231	0.82
23Ap	6180	5151	0.88	1079	1165	0.70
A-C	4745	5457	1.06	1315	1262	0.79
C	5236	5681	1.18	1593	1328	0.81
24Ap	4690	6238	1.24	1119	1045	0.68
A-C	5645	7178	1.27	1598	1663	0.87
C	5730	6530	1.34	1651	1717	0.95

Table 19.-Phosphorus, sulphur, carbon and nitrogen contents of the Sharkey group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic Matter	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	%	
1Ap	992	1287	10	2.98	1.73	0.128	13.5
A-C	502	740	6	1.93	1.12	0.100	11.2
C	313	668	6	1.18	0.68	0.083	8.2
2Ap	180	494	8	3.86	2.24	0.160	14.0
A-C	112	384	8	1.66	0.74	0.153	11.4
C	246	450	6	0.76	0.44	0.158	9.1
3Ap	124	483	20	2.76	1.60	0.131	12.2
A-C	128	468	16	2.45	1.42	0.127	11.2
C	125	398	12	1.07	0.62	0.079	7.8
4Ap	168	639	8	3.59	2.08	0.152	13.7
A-C	184	488	6	1.38	0.80	0.090	8.9
C	215	572	6	1.31	0.76	0.080	9.5
5Ap	257	969	12	3.78	2.19	0.151	14.5
A-C	219	524	10	1.50	0.87	0.080	10.9
C	240	519	6	1.38	0.80	0.080	10.0
6Ap	150	549	10	3.34	1.94	0.163	11.9
A-C	217	492	8	1.50	0.87	0.090	9.7
C	269	506	8	1.57	0.91	0.098	9.3
7Ap	193	551	8	4.02	2.33	0.170	13.7
A-C	121	373	14	2.31	1.34	0.119	11.3
C	241	448	12	1.34	0.78	0.089	8.8
8Ap	154	581	8	2.65	1.54	0.127	12.1
A-C	171	518	4	2.62	1.52	0.126	12.1
C	234	541	4	1.57	0.91	0.093	9.8
9Ap	124	720	14	2.99	1.74	0.142	12.3
A-C	95	606	10	1.41	0.82	0.093	8.8
C	111	588	10	1.17	0.68	0.076	8.9
10Ap	173	783	24	3.86	2.24	0.193	11.6
A-C	122	714	18	2.93	1.70	0.149	11.4
C	106	686	8	2.50	1.45	0.153	9.5
11Ap	200	709	14	3.45	2.00	0.140	14.3
A-C	227	571	10	1.57	0.91	0.095	9.6
C	168	497	8	1.41	0.82	0.072	11.4
12Ap	266	692	16	2.69	1.56	0.112	13.9
A-C	252	691	8	1.74	1.01	0.097	10.4
C	282	704	12	1.24	0.72	0.080	9.0

(Continued)

Table 19.-(Continued) Phosphorus, sulphur, carbon and nitrogen contents of the Sharkey group soils.

Loc. No. and Horizon	Extract. P	Total P	Extract. S	Organic Matter	Organic C	Total N	C/N Ratio
	ppm	ppm	ppm	%	%	%	
13Ap	235	822	12	2.71	1.57	0.127	12.4
A-C	203	630	10	3.14	1.82	0.155	11.7
C	200	621	8	1.76	1.02	0.100	10.2
14Ap	181	929	8	3.43	1.99	0.139	14.3
A-C	197	786	4	1.69	0.98	0.094	10.4
C	204	751	6	1.36	0.79	0.069	11.4
15Ap	230	949	8	3.29	1.91	0.139	13.7
A-C	226	594	8	1.69	0.98	0.080	12.3
C	231	617	4	1.76	1.02	0.072	14.2
16Ap	291	1120	6	3.60	2.09	0.140	14.9
A-C	222	675	4	1.43	0.83	0.087	9.5
C	198	635	6	1.34	0.78	0.078	10.0
17Ap	189	976	10	3.69	2.14	0.171	12.5
A-C	166	631	12	2.90	1.68	0.126	13.3
C	178	526	4	2.07	1.20	0.105	11.4
18Ap	159	791	8	4.19	2.43	0.184	13.2
A-C	177	742	6	1.88	1.09	0.097	11.2
C	255	675	6	1.34	0.78	0.075	10.4
19Ap	186	702	10	3.41	1.98	0.152	13.0
A-C	213	715	6	1.88	1.09	0.067	16.3
C	180	497	8	1.76	1.02	0.075	13.6
20Ap	547	953	28	4.70	2.73	0.155	17.6
A-C	600	939	18	4.07	2.36	0.145	16.3
C	208	956	12	2.09	1.21	0.080	15.1
21Ap	176	659	10	3.60	2.09	0.179	11.7
A-C	174	583	4	2.07	1.20	0.100	12.0
C	177	679	4	1.81	1.05	0.094	11.2
22Ap	707	1529	12	3.41	1.98	0.140	14.1
A-C	229	670	8	1.95	1.13	0.094	12.0
C	263	678	6	1.60	0.93	0.084	11.1
23Ap	203	700	14	3.10	1.80	0.158	11.4
A-C	235	444	8	1.76	1.02	0.096	10.6
C	281	405	6	1.51	0.88	0.082	10.7
24Ap	243	770	8	4.20	2.44	0.165	14.8
A-C	215	590	8	1.76	1.02	0.080	12.8
C	267	604	4	1.62	1.94	0.081	11.6

Table 20.-Clay content, exchange properties, and pH value of the Sharkey group soils.

Loc. No. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./100g	m.e./100g	m.e./100g	%	
1Ap	54.74	42.38	2.18	40.20	94.86	7.2
A-C	63.52	45.97	1.32	44.65	97.13	7.5
C	61.79	42.89	0.55	42.34	98.72	7.6
2Ap	56.50	37.46	2.88	34.58	92.31	6.5
A-C	61.93	46.90	0.75	46.15	98.40	7.4
C	64.30	44.44	0.48	43.96	98.92	7.5
3Ap	47.49	35.32	1.71	33.61	95.16	6.3
A-C	48.92	36.93	2.81	34.12	92.39	6.3
C	60.91	42.21	2.58	39.63	93.89	6.8
4Ap	59.16	42.72	4.22	38.50	90.12	6.0
A-C	62.11	43.55	2.23	41.32	94.88	6.8
C	61.54	42.73	1.69	41.04	96.04	7.0
5Ap	51.55	41.33	4.23	37.10	89.77	6.4
A-C	49.02	41.79	1.65	40.14	96.05	7.2
C	52.46	43.94	1.28	42.66	97.10	7.4
6Ap	66.40	50.86	3.22	47.64	93.67	6.4
A-C	67.36	50.71	0.00	50.71	100.00	7.5
C	62.05	50.33	0.00	50.33	100.00	7.5
7Ap	63.75	49.23	3.05	46.18	93.80	7.0
A-C	65.93	45.96	0.93	45.03	97.98	7.4
C	61.54	45.42	0.00	45.42	100.00	7.7
8Ap	65.65	45.92	2.88	43.04	93.73	6.5
A-C	66.60	45.99	2.10	43.89	95.43	7.0
C	57.93	43.32	0.93	42.39	97.85	7.3
9Ap	55.53	38.64	4.08	34.56	89.44	6.0
A-C	69.52	43.51	2.32	41.19	94.67	6.5
C	51.34	36.47	1.95	34.52	94.65	6.5
10Ap	56.41	45.28	1.85	43.43	95.91	6.8
A-C	63.84	43.25	1.68	41.57	96.12	6.8
C	69.65	45.63	1.35	44.28	97.04	7.0
11Ap	60.07	41.91	3.68	38.23	91.22	6.2
A-C	67.36	43.61	0.21	43.40	99.52	7.3
C	68.65	45.41	0.00	45.41	100.00	7.6
12Ap	41.07	36.55	1.70	34.85	95.35	6.8
A-C	52.57	37.84	1.59	36.25	95.80	6.8
C	49.95	33.86	1.43	32.43	95.78	7.0

(Continued)

Table 20.-(Continued) Clay content, exchange properties, and pH value of the Sharkey group soils.

Loc. No. and Horizon	Clay	Cation Exchange Capacity	Exch. H	Total Exch. Bases	Base Sat.	pH
	%	m.e./100g	m.e./100g	m.e./100g	%	
13Ap	73.45	49.32	1.38	47.94	97.20	7.0
A-C	70.44	46.26	0.20	46.06	99.57	7.3
C	67.53	45.23	0.00	45.23	100.00	7.6
14Ap	63.58	47.08	1.98	45.10	95.79	6.8
A-C	66.60	45.77	0.00	45.77	100.00	7.6
C	68.44	59.47	0.00	59.47	100.00	7.7
15Ap	57.11	41.78	3.35	38.43	91.98	6.4
A-C	68.88	41.65	0.61	41.04	98.54	7.3
C	66.60	38.85	0.20	38.65	99.49	7.6
16Ap	67.81	40.18	3.68	36.50	90.84	6.4
A-C	76.35	44.54	1.76	42.78	96.05	7.4
C	72.85	42.93	0.00	42.93	100.00	7.6
17Ap	59.77	38.91	4.53	34.38	88.36	5.9
A-C	65.39	40.66	2.10	38.56	94.84	6.8
C	67.50	40.21	1.09	39.12	97.29	7.3
18Ap	65.65	47.53	4.38	43.15	90.78	6.0
A-C	69.23	43.99	1.28	42.71	97.09	7.1
C	67.08	43.61	0.93	42.68	97.87	7.2
19Ap	64.30	43.95	1.95	42.00	95.56	6.8
A-C	69.52	44.68	0.00	44.68	100.00	7.5
C	78.75	51.52	0.00	51.52	100.00	7.6
20Ap	33.37	32.25	1.85	30.40	94.26	6.8
A-C	34.87	33.43	1.40	32.03	95.81	7.1
C	53.96	34.75	0.00	34.75	100.00	7.6
21Ap	65.31	46.16	3.34	42.82	92.76	6.3
A-C	67.32	44.95	1.52	43.43	96.62	7.1
C	62.83	42.01	1.51	40.50	96.41	6.8
22Ap	53.44	41.70	3.44	38.26	91.75	7.0
A-C	65.24	42.70	1.37	41.33	96.79	7.1
C	56.88	37.30	1.24	36.06	96.68	7.0
23Ap	53.50	39.55	3.98	35.57	89.94	6.3
A-C	58.66	38.72	0.81	37.91	97.91	7.2
C	58.90	39.81	0.21	39.60	99.47	7.4
24Ap	41.32	41.13	1.14	39.99	97.23	7.3
A-C	78.04	50.41	0.53	49.88	98.95	7.5
C	79.87	47.10	0.00	47.10	100.00	7.5

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Influence of Annual Applications of PHOSPHORUS on the Yield and Chemical Composition of Common Bermudagrass and on the Chemical Composition of a Bowie Soil

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Influence of Annual Applications of Phosphorus on the Yield and Chemical Composition of Common Bermudagrass and on the Chemical Composition of a Bowie Soil

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INTRODUCTION

There are large acreages of Bowie soils in Southwest Louisiana and neighboring states. These soils are very low in phosphorus (P) and are utilized extensively in the production of forage for livestock. Brupbacher et al. (*2*)[2] found that 62 percent of the soils from the Coastal Plain area of Louisiana were low in extractable P and 63 percent of the soils from the Flatwoods area of Southwest Louisiana were low in extractable P. Both of these soil areas contain large acreages of Bowie soils. Bermudagrass is the most widely grown perennial grass for livestock throughout these soil areas. Experiments to determine the response of crops, such as bermudagrass, to rates of the various fertilizer elements have always been an important part of research. However, most studies have not combined crop response with soil test calibration data as one of the principal objectives.

The objectives of this investigation were: (1) to determine the influence of annual applications of P on the yield and chemical composition of common bermudagrass grown on Bowie fine sandy loam soil and (2) to relate the annual applications of P to the P content of the soil and to forage yield. The data could be used as an aid in interpreting soil test results and making fertilizer recommendations based on soil tests.

This investigation was conducted as part of Regional Project S-52. The states cooperating in this investigation were Texas, Oklahoma, Arkansas and Louisiana. Data presented in this publication include only the results obtained in the experiment conducted in Louisiana.

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[2] Italic numbers in parentheses refer to Literature Cited, Page 35.

REVIEW OF LITERATURE

Numerous investigators have studied the effects of P fertilization on the yield of bermudagrass and other pasture grasses. Burton et al. (*3*) stated that the application of large quantities of P and potassium (K) to Coastal bermudagrass increased the protein, carotene and xanthophyll contents very little. There appeared to be no reason to apply more than the minimum rates of P and K needed for optimum production.

Cope (*4*) reported that Coastal bermudagrass showed little response to applied P unless the soil supply was very deficient. He found that Coastal bermudagrass did not remove large amounts of P from the soil. One ton of hay contained only about four pounds of P or nine pounds of P_2O_5.

Ensminger (*5*) stated that the extent of P accumulation depended on such factors as the amount of P added, amount lost by erosion, crops grown and how much of the crop was removed from the land. He found that six tons of Coastal bermudagrass hay removed 54 pounds of P_2O_5 per acre. It was concluded that the P fixed by the soil was important in crop production and should be considered in making fertilizer recommendations. Harris (*6*) studied the effect of three sources of P on the growth of grass on a Bowie very fine sandy loam soil. He found a significant correlation between the forage yield of a perennial grass and the amount of extractable P in the soil. Ensminger (*5*) also found that the extractable P content of soils was directly related to yield response to residual P.

Rouse (*9*) studied the relationship between P in the top two inches of soil and the relative yield of Coastal bermudagrass. Luxury consumption of P occurred when the bermudagrass contained above 0.16 percent P. The maximum yield of grass was obtained with a soil test value of about 30 ppm of P. Jordan et al. (*8*) presented data that showed a yield response to P at soil test values of less than 25 ppm of P. Woodhouse (*10*) reported that about 25 ppm of extractable P in the plow layer and a P content of 0.15 to 0.20 percent in the plant tissue appeared to be adequate for the growth of Coastal bermudagrass. Jordan et al. (8) also found that above 0.16 percent P in the Coastal bermudagrass was adequate for maximum production.

Woodhouse (*10*) found that where 12 kg of P per ha (10.7 lbs. per acre) were applied annually, the removal was 13 kg per ha (11.6 lbs. per acre) annually, indicating an apparent recovery rate of 75 percent of the applied P. Soil test data showed evidence of substantial penetration of applied P into the 15-30 cm (5.9-11.8 in.) zone and some indication of movement to the 30-46 cm (11.8-18.1 in.) depth. It was reported by Hileman et al. (*7*) that after four years of applying 600-300-300 to common bermudagrass, the extractable P content in the soil increased from 15 pounds per acre to 114 pounds per acre. Jordan et al. (*8*) concluded that the chemical analysis of samples from the surface two inches of soil was representative of the P fertility.

EXPERIMENTAL PROCEDURE

An investigation on the effects of annual applications of P on the yield and chemical composition of common bermudagrass and on soil test values was initiated in 1965 and continued through 1970. The experiment was conducted on a Bowie fine sandy loam soil at the West Louisiana Agricultural Experiment Station near Rosepine, Louisiana.

The experimental design used in this study was a randomized complete block. The plot size was 7 x 14 feet with 4-foot alleys between plots. Each treatment was replicated six times.

Surface and subsoil samples were taken from each plot prior to the application of fertilizer each year to determine changes in the fertility and lime status of the soil. Initially, the soil contained 5 ppm of P and was uniform in P content throughout the experimental area. Initially, the soil contained 79 ppm of K, 483 ppm of calcium (Ca) and 92 ppm of magnesium (Mg). The soil reaction was pH 5.8.

The P treatments were 0, 13, 26, 39, 52 and 66 pounds of P per acre applied annually as a broadcast application in early spring. Concentrated superphosphate containing 22.9 percent P (52% P_2O_5) served as the source of P. Potassium was applied annually at the rate of 200 pounds per acre as KCl. Dolomitic limestone was applied to the soil at the rate of two tons per acre prior to the establishment of bermudagrass. An additional one ton per acre surface application of dolomitic limestone was applied in the spring of 1967. All plots received 100 pounds of nitrogen (N) per acre as ammonium nitrate after each cutting in 1965 and 1966 and 50 pounds of N per acre after each cutting in 1967, 1969 and 1970. The stand of bermudagrass was lost in 1968 because of disease, and all plots had to be reestablished. The experimental area was fumigated with methyl bromide before reestablishment in order to control weeds. Yield data were not obtained in 1968.

Forage from all plots was harvested two to five times each year depending on the amount of growth. Representative samples of forage were taken from each plot at each harvest for moisture determinations and chemical analyses. Plant samples from the six replications of each treatment were dried to a constant weight at 70C. After drying, the plant samples were ground in a stainless steel Wiley mill to pass a 20-mesh screen. The samples of plant material from each treatment of the six replications were composited and stored in glass containers for chemical analysis.

Phosphorus, K, Ca and Mg were determined on the plant samples. A two-gram sample of forage was dry-ashed in a muffle furnace at 500C for one hour. The ash was taken up with 10 ml of five-normal hydrochloric acid, filtered and made up to a volume of 100 ml. An aliquot of this solution was used to determine the content of P, K, Ca and Mg in the plant material. Phosphorus was determined by the vanadate – molybdate – yellow method. The concentrations of K, Ca and Mg were determined on the atomic absorption spectrophotometer.

The analytical methods and procedures used to determine the fertility level and lime status of the soil samples are described in Louisiana Agricultural Experiment Station Bulletin No. 632 (*1*). Soil reaction (pH) was determined by using a pH-meter and a slurry of soil and distilled water at a soil-to-water ratio of approximately 1:1. Phosphorus was determined by extracting a sample of soil with a solution of 0.10 *N* HCl containing 0.03 *N* NH_4F. A soil-to-solution ratio of 1:20 and an extracting period of 15 minutes were used to determine extractable P. Potassium, Ca and Mg were determined by extracting a sample of soil with a 0.10 *N* HCl solution using a soil-to-solution ratio of 1:20. The extraction time was 15 minutes.

The forage yield data were reported on a dry weight basis and were statistically analyzed by the analysis of variance method.

RESULTS AND DISCUSSION

The data in Table 1 show the effect of annual applications of P on the forage yield of common bermudagrass grown on Bowie fine sandy loam soil. Significant differences in forage yield due to levels of applied P were obtained each year of the investigation.

In 1965, significant increases in forage yield were obtained with each level of applied P up to the 66-pound rate. During the second year, 1966, significant increases in forage yield were found among increments

Table 1.-The effect of annual applications of P on the forage yield of common bermudagrass grown on Bowie fine sandy loam soil, 1965-1970.1/

P applied annually	1965	1966	1967	1969	1970
lbs. per acre	-----Yield of dry forage, tons per acre-----				
0	1.42	3.09	1.03	1.53	4.77
13	2.64	6.23	2.85	2.77	6.58
26	3.33	8.24	4.14	3.31	6.15
39	3.95	9.45	5.04	3.84	6.46
52	4.32	10.14	4.88	3.91	6.76
66	4.78	10.35	5.60	4.24	6.81
LSD at 5%	0.32	0.30	0.27	0.35	0.41

1/Yield data were not obtained in 1968 due to loss of bermudagrass stand.

of applied P up to the 52-pound level. The forage yields on all of the plots in 1966 were consistently higher than the yields the previous year.

Forage yields in 1967 were increased significantly by each increment of applied P up to the 39-pound rate. The yield produced at the 39-pound rate of P was not significantly different from the yield at the 52-pound rate. However, when 66 pounds of P were applied per acre in 1967, the forage yields were significantly higher than the yields produced at all other P levels.

Forage yields were not taken in 1968 due to loss of the bermudagrass stand from *Rhizoctonia solani*. However, soil samples were collected for chemical analyses prior to the application of each of the rates of P.

Relatively lower forage yields were obtained in 1969 as compared with yields in previous years and this was probably due to the loss of stand and the reestablishment of the grass on all plots. Significant increases in forage yield were obtained with P applications up to the 39-pound rate of P.

In 1970, the application of 13 pounds of P per acre resulted in a significant increase in yield. Higher rates of P did not cause further significant increases in yield. This result indicated that a buildup in soil P had occurred during the course of the investigation.

The pounds of common bermudagrass forage produced per pound of applied P are shown in Table 2. These data show that as the amount of applied P was increased there was a decrease in the production of forage per pound of applied P. This decrease occurred during each year of the experiment. During the second year, the yield of forage per pound of applied P was relatively high at all rates of applied P. This was primarily due to the high forage yields that were obtained in 1966 as a result of P applications along with a very favorable growing season. At that time a large buildup of P had not occurred in the

Table 2.-Pounds of common bermudagrass forage produced per pound of applied P-1965-1970.1/

P applied annually	1965	1966	1967	1969	1970
lbs. per acre	--Pounds of dry forage per pound of applied P				
13	188	483	280	191	278
26	147	396	239	137	106
39	130	326	206	118	87
52	112	271	148	92	77
66	102	220	138	82	62

1/Yield data were not obtained in 1968 due to loss of bermudagrass stand.

soil, especially at the lower levels of applied P. With continued annual applications of P there was a buildup of P in the soil, as shown in Table 9. The buildup of P in the soil reduced the amount of forage produced per pound of applied P. This is indicated in the 1969 and 1970 data, especially at the higher rates of applied P.

The effect of annual applications of P on the recovery of applied P by common bermudagrass is shown in Table 3. In general, as the rates of P increased, the percentage recovery of applied P by bermudagrass decreased each year. In four of the five years the highest recovery percentage of applied P by common bermudagrass was found with an annual application of 13 pounds of P per acre. The percent recovery of applied P was exceptionally high in 1966. This was probably due to favorable growing conditions and the large forage yields produced that year. In 1966, there was an 88.9 percent recovery of the applied P at the 13-pound rate of applied P, and a 63.5 percent recovery at the 66-pound rate of applied P. The lowest recovery of applied P was obtained during the first year of the study. The recovery of applied P by common bermudagrass tended to increase or decrease in relation to forage yield.

Table 3.-The effect of annual applications of P on the recovery of applied P by common bermudagrass - 1965-1970.1/

P applied annually	1965	1966	1967	1969	1970
lbs. per acre	-------------P recovered-%------------------				
13	29.2	88.9	43.9	38.2	64.5
26	24.5	83.5	46.3	31.5	46.2
39	25.7	83.9	45.2	31.3	40.8
52	22.5	73.3	34.1	23.3	35.9
66	21.0	63.5	34.7	25.9	32.3

1/Yield data were not obtained in 1968 due to loss of bermudagrass stand.

The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass in 1965 is shown in Table 4. The relationship between forage yield and P uptake is further illustrated in Figure 1. Significant increases in the yield of forage were obtained from each increment of applied P up to the 66-pound rate. The maximum yield of 4.78 tons of dry forage per acre was obtained from the application of 66 pounds of P per acre. As the rates of applied P increased there was an increase in content of P in the forage. The P content of the forage varied from 0.134 percent in

Table 4.-The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass, 1965.

P applied	Yield of dry forage[1/]	P	P-uptake	K	K-uptake	Ca	Ca-uptake	Mg	Mg-uptake
lbs/acre	tons/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre
0	1.42	0.134	3.80	1.75	49.58	0.348	9.85	0.174	4.92
13	2.64	0.144	7.59	1.80	94.87	0.399	21.03	0.166	8.74
26	3.33	0.153	10.18	1.88	125.03	0.402	26.75	0.175	11.67
39	3.95	0.175	13.83	1.94	152.95	0.403	31.83	0.167	13.23
52	4.32	0.179	15.48	2.00	173.21	0.389	33.65	0.167	14.47
66	4.78	0.185	17.69	2.13	203.13	0.405	38.73	0.165	15.77
L.S.D. at 5%	0.32								

[1/] Total yield for three cuttings.

the check plot to 0.185 percent in forage produced at the 66-pound rate of applied P. The removal of P from the soil by common bermudagrass in 1965 also increased as the rates of applied P increased, with the highest removal of P occurring at the 66-pound rate. The P uptake by bermudagrass ranged from 3.80 pounds per acre where no P was applied to 17.69 pounds per acre where 66 pounds of P per acre were applied.

The content of K in the forage and the K uptake per acre increased with each increment of applied P, as shown in Table 4. The concentration of K in the forage ranged from 1.75 percent in forage from the plots that did not receive P to 2.13 percent in the forage from the 66-pound rate of P. At the 66-pound rate of applied P, the K uptake was 203 pounds per acre, as compared with an uptake of only 49 pounds per acre when no P was applied. The increased uptake of K by the bermudagrass following the addition of each increment of applied P was attributed to increased production of dry matter that resulted from the applied P.

The content of Ca tended to increase slightly in the bermudagrass forage with increased rates of applied P. The highest percentage of Ca in the forage was found at the 66-pound rate of applied P. With each increase in applied P there was a corresponding increase in the amount of Ca taken up by the bermudagrass. The highest removal of Ca was obtained at the 66-pound rate of applied P.

In 1965, the P treatments resulted in relatively small changes in the Mg content of the grass. The Mg content of the bermudagrass was

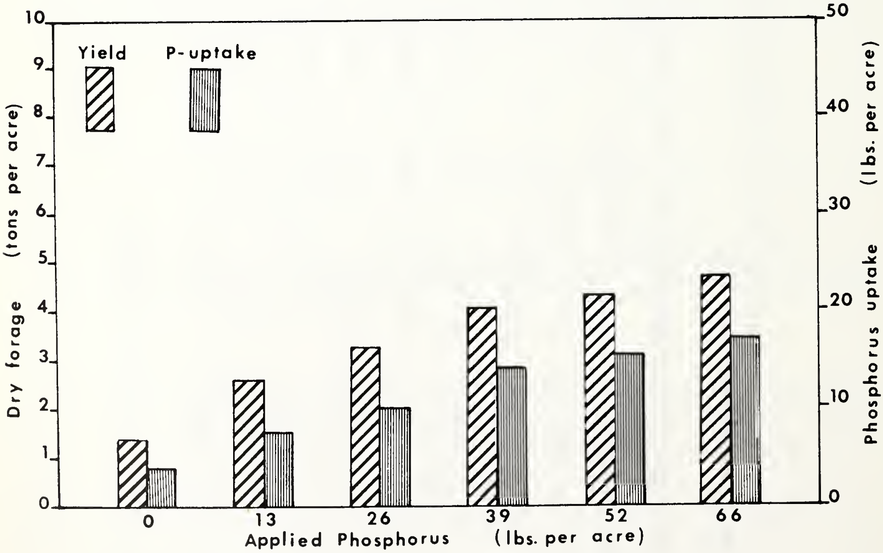

Fig. 1—The effect of applied phosphorus on the forage yield and phosphorus uptake of common bermudagrass in 1965.

slightly lower at the higher levels of applied P. Magnesium uptake per acre was increased at the higher rates of applied P due to the increase in forage production with the higher levels of P.

The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass in 1966 is shown in Table 5. The relationship between forage yield and P uptake is further illustrated in Figure 2. The same increments of P were used in the spring of 1966 as were used the previous year. Significant increases in the yield of forage were obtained from each increment of applied P up to the 52-pound rate. The maximum forage yield of 10.3 tons of dry forage per acre resulted from the application of 66 pounds of P per acre. However, this yield was not significantly higher than the yield obtained with 52 pounds of applied P per acre. The content of P in the forage and the P uptake from the soil increased with each increment of applied P. When P was not applied the P content of the bermudagrass was lower in 1966 than during the previous year. However, in all other P treatments in 1966 the content of P in the bermudagrass forage was higher than in the previous year. Forage produced with no applied P contained 0.115 percent P, while forage produced with 66 pounds of applied P per acre contained 0.237 percent P. In 1966, common bermudagrass removed 7.12 pounds of P per acre from the untreated soil. The highest uptake of P, 49.04 pounds per acre, occurred at the 66-pound rate of applied P. The uptake of P was considerably higher from all treatments in 1966 than it was in 1965. The large amounts of P removed by the grass in 1966 were due to the larger tonnage of forage produced and a slightly higher P concentration in the grass as compared with the 1965 data.

In 1966, the K content of the forage decreased at the higher levels of applied P, as shown in Table 5. Forage produced at the 13-pound rate of P contained the highest percentage of K. The lowest concentration of K in the forage occurred with the 66-pound rate of P. The K uptake was variable; however, increased uptake of K was noted with increments of applied P up to 26 pounds per acre. Above the 26-pound rate of P the K removal from the soil showed no further increase. Considerably higher removal of K per acre occurred in 1966 as compared with the 1965 data in Table 4. This was probably due to the increased forage yields obtained on all of the plots in 1966.

There were only small increases in the Ca content of the forage in 1966 due to variations in applied P. The Ca percentage of the bermudagrass was slightly higher in 1966 than in the previous year. Calcium uptake increased with each of the increments of applied P. This was due to the increased yield of forage resulting from the applications of P.

As the rates of applied P increased there was a slight increase in the Mg content of the forage and an increase in Mg uptake. Where P was not applied, the forage contained 0.156 percent Mg. Forage produced at the 66-pound rate of P contained 0.202 percent Mg. The Mg uptake

Table 5.-The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass, 1966.

P applied	Yield of dry forage[1/]	P	P-uptake	K	K-uptake	Ca	Ca-uptake	Mg	Mg-uptake
lbs/acre	tons/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre
0	3.09	0.115	7.12	1.89	117.15	0.475	29.40	0.156	9.68
13	6.23	0.150	18.68	2.11	262.78	0.486	60.51	0.168	20.88
26	8.24	0.175	28.84	2.04	336.14	0.480	79.06	0.177	29.24
39	9.45	0.211	39.86	1.50	282.82	0.515	97.33	0.188	35.50
52	10.14	0.223	45.22	1.48	299.20	0.500	101.23	0.196	39.74
66	10.35	0.237	49.04	1.43	294.92	0.512	106.05	0.202	41.79
L.S.D. at 5%	0.30								

[1/] Total yield for five cuttings.

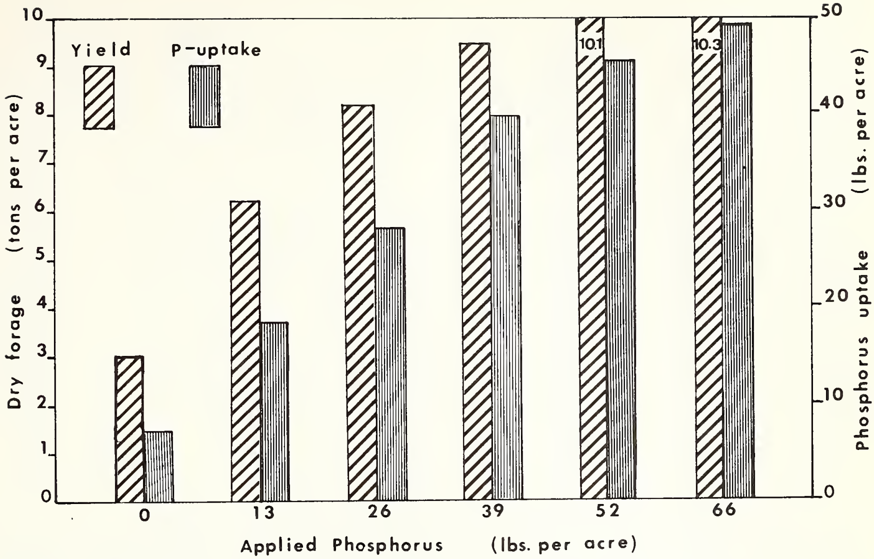

Fig. 2—The effect of applied phosphorus on the forage yield and phosphorus uptake of common bermudagrass in 1966.

by the bermudagrass increased from 9.68 pounds per acre where P was not applied to 41.79 pounds per acre at the 66-pound level of applied P.

The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass in 1967 is shown in Table 6. The relationship between forage yield and P uptake is further illustrated in Figure 3. Significant increases in forage yield were obtained with increased rates of applied P up to the 39-pound rate. At the 52-pound rate of P there was a slight but non-significant decrease in yield as compared with the yield obtained at the 39-pound rate. The maximum forage yield was obtained from the treatment receiving the highest rate of applied P. Forage yields in 1967 were similar to the yields obtained in 1965 and were considerably less than the yields of 1966. In 1967, the content of P in the forage and the P uptake from the soil increased with each increment of applied P. Where no P was applied, the common bermudagrass contained 0.125 percent P, while the forage produced at the 66-pound rate of P contained 0.228 percent P. The P uptake with 66 pounds of applied P was 25.49 pounds per acre, as compared with a P uptake of 2.59 pounds per acre from the treatment that did not receive P.

The K concentration of the bermudagrass forage in 1967 decreased at the higher levels of applied P, as shown in Table 6. The highest content of K in the forage was 1.99 percent with an application of 13 pounds of P per acre. The K concentration in the forage decreased to 1.75 percent at the 66-pound rate of applied P. The K uptake increased

Table 6.-The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass, 1967.

P applied	Yield of dry forage[1/]	P	P-uptake	K	K-uptake	Ca	Ca-uptake	Mg	Mg-uptake
lbs/acre	tons/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre
0	1.03	0.125	2.59	1.95	40.18	0.330	6.27	0.183	3.77
13	2.85	0.176	8.30	1.99	113.43	0.335	19.13	0.174	9.95
26	4.14	0.177	14.64	1.84	151.86	0.327	27.06	0.174	14.40
39	5.04	0.200	20.20	1.81	182.81	0.325	32.94	0.184	18.64
52	4.88	0.208	20.30	1.77	172.96	0.326	31.77	0.196	19.10
66	5.60	0.228	25.49	1.75	195.95	0.329	36.81	0.187	20.92

L.S.D. at 5% 0.27

[1/] Total yield for four cuttings.

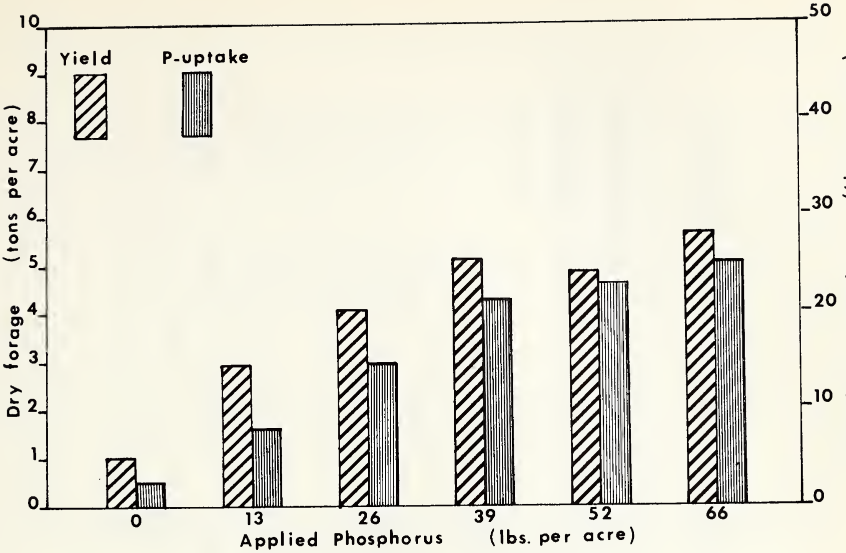

Fig. 3—The effect of applied phosphorus on the forage yield and phosphorus uptake of common bermudagrass in 1967.

with increased rates of applied P and forage yield. Potassium uptake ranged from approximately 40 pounds per acre with no applied P to 196 pounds per acre at the 66-pound rate of P.

The data in Table 6 also show that the P treatments had very little influence on the Ca and Mg concentrations in the plant tissue and on uptake of these two elements. The uptake of Ca and Mg by the grass varied in relation to the yield of forage.

The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass in 1969 is shown in Table 7. The relationship between yield and P uptake in 1969 is further illustrated in Figure 4. Significant increases in forage yield were obtained with each increase in applied P up to the 39-pound rate of P. The maximum forage yield was produced from the application of 66 pounds of P per acre. This yield was significantly higher than the yield produced at the 39-pound rate of P, but not significantly higher than the yield produced at the 52-pound rate. The concentration of P in the forage and the P uptake increased with increased rates of P up to the 39-pound rate of P. Phosphorus content of the forage and P uptake were slightly lower at the 52-pound rate of applied P, but increased at the 66-pound level. The highest removal of P occurred with the application of 66 pounds of P per acre.

The concentration of K in the bermudagrass was variable at the different levels of applied P in 1969, as shown in Table 7. However, the K uptake per acre increased with corresponding increases in forage yield at each level of applied P. Approximately 176 pounds of K per

Table 7.-The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass, 1969.

P applied	Yield of dry forage[1/]	P	P-uptake	K	K-uptake	Ca	Ca-uptake	Mg	Mg-uptake
lbs/acre	tons/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre
0	1.53	0.115	3.52	1.60	48.96	0.258	7.89	0.194	5.94
13	2.77	0.153	8.48	1.99	110.25	0.258	14.29	0.154	8.53
26	3.31	0.177	11.72	1.82	120.48	0.255	16.88	0.151	10.00
39	3.84	0.205	15.74	1.78	136.70	0.254	19.51	0.164	12.60
52	3.91	0.200	15.64	1.81	141.54	0.259	20.25	0.151	11.81
66	4.24	0.243	20.61	2.08	176.38	0.251	21.28	0.167	14.16

L.S.D. at 5% 0.35

[1/] Total yield for two cuttings.

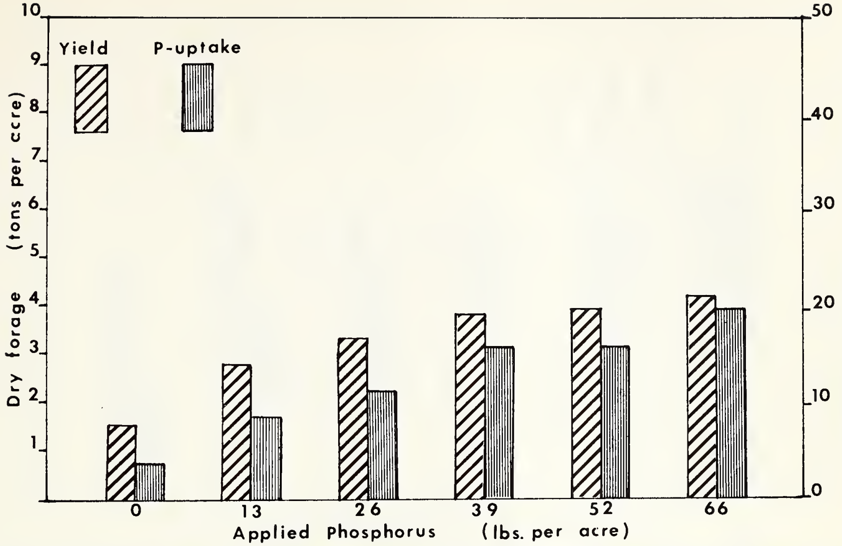

Fig. 4—The effect of applied phosphorus on the forage field and phosphorus uptake of common bermudagrass in 1969.

acre were removed from the soil on plots that received the 66-pound rate of applied P.

In 1969, the Ca concentration of the forage was not affected by rates of applied P. The uptake of Ca per acre increased in relation to forage yield increases at the different rates of applied P.

The data in Table 7 show that forage from the no-P treatment had the highest concentration of Mg in 1969. The varying levels of applied P had little effect on the Mg concentration in the grass. In general, the Mg uptake varied in relation to forage yield.

The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass in 1970 is shown in Table 8. The relationship between forage yield and P uptake is further illustrated in Figure 5. The data show that the maximum forage yield was obtained at the 66-pound rate of applied P. However, no significant yield increases were obtained from applications of P above the 13-pound rate. There was an increase in the P concentration in the forage and the P uptake for each increase in applied P.

The K concentration of the forage did not appear to be affected by the different rates of applied P in 1970, as shown in Table 8. Potassium uptake was higher than in the previous year due to the increased forage yields in 1970.

Calcium concentration in the bermudagrass was not affected by the different rates of applied P in 1970. The uptake of Ca per acre was related to forage yield.

The Mg concentration in the forage increased slightly with increases

Table 8.-The effect of applied P on the total forage yield, chemical composition and nutrient uptake of common bermudagrass, 1970.

P applied	Yield of dry forage[1/]	P	P-uptake	K	K-uptake	Ca	Ca-uptake	Mg	Mg-uptake
lbs/acre	tons/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre	%	lbs/acre
0	4.77	0.119	11.35	1.56	148.73	0.328	31.29	0.160	15.26
13	6.58	0.150	19.74	1.64	215.17	0.343	45.13	0.186	24.48
26	6.15	0.190	23.37	1.54	188.93	0.341	41.94	0.196	24.11
39	6.46	0.211	27.26	1.70	219.25	0.314	40.57	0.216	27.91
52	6.76	0.222	30.01	1.66	223.89	0.321	43.40	0.237	32.04
66	6.81	0.240	32.69	1.64	223.64	0.329	44.81	0.220	29.96
L.S.D. at 5%	0.41								

[1/] Total yield for three cuttings.

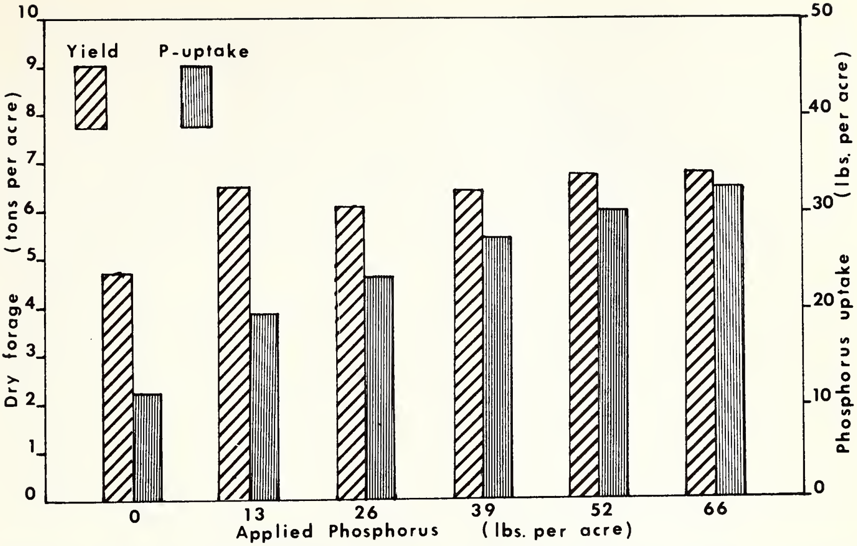

Fig. 5—The effect of applied phosphorus on the forage yield and phosphorus uptake of common bermudagrass in 1970.

in applied P up to the 52-pound rate of P. At the 66-pound rate of P there was a slight decrease in the Mg content of the grass. In general, the Mg uptake was related to the forage yield. However, at the 66-pound rate of P there was a decrease in the Mg uptake.

The P status of Bowie fine sandy loam soil following annual applications of P is shown in Table 9. In 1965, prior to the application of the P treatments, the soil contained 5 ppm of extractable P. During each year of the experiment the P status of the soil was determined in the spring prior to the annual application of the P treatments. In 1966, 1967, 1968, 1970 and 1971 soil samples were taken at the 0-1 inch depth and at the 1-6 inch depth. In 1969, soil samples were taken at a depth of 0-5 inches.

The data in Table 9 show that in 1966, after one application of the P treatments, there was a considerable increase in the P content of the soil. This was especially true at the 0-1 inch soil depth. With the application of 13 pounds of P per acre, the 0-1 inch soil depth contained 8 ppm of extractable P. The extractable P increased in the 0-1 inch depth with each increased rate of applied P. With the addition of 66 pounds of P per acre, the P content in the soil was 66 ppm at the 0-1 inch depth. At the 1-6 inch soil depth, there was no increase in extractable P with the application of 13 pounds of P per acre. However, with applications of P above 13 pounds per acre, the P content at the 1-6 inch soil depth increased slightly with each increase in applied P in 1966. The highest content of extractable P at the 1-6 inch depth was 16 ppm. This occurred at the 66-pound rate of applied P.

Table 9.-The P status of Bowie fine sandy loam soil following annual applications of P.

P	1966		1967		1968		1969[1/]	1970		1971	
applied	Depth		Depth		Depth		Depth	Depth		Depth	
annually	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-5 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.
lbs/acre	-----Extractable P, ppm-----										
0	5	5	7	3	7	4	12	17	13	10	6
13	8	5	12	3	16	4	13	37	14	34	8
26	14	7	22	3	26	4	18	43	17	55	12
39	20	11	47	5	46	5	29	65	22	81	22
52	37	12	76	5	75	4	39	103	30	140	39
66	66	16	117	11	111	5	52	127	37	172	53

[1/] Experimental area was renovated in 1969.

In 1967, further increases in extractable P were obtained at the 0-1 inch soil depth with each increase in applied P. There was a considerable buildup of P in the top inch of soil in 1967 as well as in the previous year. The 0-1 inch depth of soil contained 12 ppm of extractable P at the 13-pound P treatment. With the application of 66 pounds of P per acre, there were 117 ppm of P in the top inch of soil in 1967. However, at the 1-6 inch soil depth, a decrease occurred in the P content as compared with the previous year. This decrease was probably due to the large removal of P by the bermudagrass during the 1966 growing season.

Yield data were not taken in 1968 due to the loss of the bermudagrass stand. However, soil samples were collected in the spring at both depths and the P treatments were applied as in previous years of the experiment. The extractable P content of the soil at the 0-1 inch depth in 1968 increased with each of the increments of applied P. However, extractable P in the top inch of soil changed very little as compared with the previous year. At the 1-6 inch soil depth, the extractable P was still low regardless of the amount of applied P. There was very little change in the P content at the 1-6 inch depth in 1968 as compared with 1967 at most of the P treatments.

In the spring of 1969, after renovation and reestablishment of the bermudagrass, soil samples were taken at the 0-5 inch depth only. During the renovation and reestablishment of the grass, P from the topsoil was mixed deeper into the soil. It was also shown that some of the P was moved into the no-P treatment during the renovation.

In 1970, soil samples were taken at both the 0-1 inch depth and the 1-6 inch depth. An increase in extractable P was found at both soil depths with each increase in applied P. The 0-1 inch depth of soil contained 37 ppm of extractable P where 13 pounds of P had been applied. With the application of 66 pounds of P per acre there were 127 ppm of P in the top inch of soil. The extractable P in the top inch of soil in 1970 was considerably higher than the P content of the top soil in 1968 at all levels of applied P. At the 1-6 inch soil depth, there was a considerable increase in P content as compared with that in 1968. This increase was due to the renovation and reestablishment of the grass in 1969.

At the conclusion of the experiment in 1971, there was an increase in extractable P at the two soil depths with increased rates of applied P. The P content at the 0-1 inch depth was lower than in the previous year in the no-P treatment and at the 13-pound rate of applied P. However, at the higher rates of applied P in 1971, the level of P in the soil at the 0-1 inch depth increased over the P content of the previous year. At the 1-6 inch depth, the extractable P decreased at the lower rates of applied P, but increased at the higher rates of applied P as compared with the 1970 data.

In general, with annual applications of P, there was an increase each year in the P content of the top inch of soil at all rates of applied

P. The buildup of P in the 0-1 inch soil depth was much greater at the higher rates of applied P. Without renovation of the soil, the results showed that the extractable P content was not increased in the 1-6 inch soil depth regardless of the rates of applied P.

The K status of Bowie fine sandy loam soil following annual applications of P is shown in Table 10. Initially, the soil contained 79 ppm of extractable K. Each year of the experiment the K content of the soil was considerably higher at the 0-1 inch soil depth than at the 1-6 inch depth regardless of the amount of applied P. There was no buildup of extractable K in the soil at either of the soil depths. After renovation and reestablishment of the bermudagrass the extractable K in the soil increased considerably at both soil depths in 1970 as compared with the 1968 data. In 1971, the extractable K content of the soil decreased at both of the sampling depths as compared with the previous year.

Apparently, annual applications of P to the bermudagrass did not have a direct effect on the K status of the soil. The extractable K content of the soil varied in relation to forage production. This is shown by the fact that the soil from the no-P treatment contained the highest K content each year at both soil depths. Also, in most years, the lowest extractable K in the soil occurred with the application of 66 pounds of P per acre.

The Ca status of Bowie fine sandy loam soil following annual applications of P is shown in Table 11. Initially, the soil contained 483 ppm of extractable Ca. In 1966, the Ca content of the soil at both soil depths was slightly higher in most of the P treatments than the initial 483 ppm. However, soil samples during the second year, 1967, showed a considerable decrease in extractable Ca, especially at the 0-1 inch depth. This was probably due to the large amount of forage removed from the plots in 1966 as a result of P and N applications.

One ton of dolomitic limestone per acre was applied to all treatments in the spring of 1967 and resulted in a large increase in extractable Ca at the 0-1 inch depth in 1968. However, this surface application of dolomitic limestone had very little effect on the Ca status of the soil at the 1-6 inch depth. In fact, soil samples from most treatments showed a decrease in Ca in 1968 at the 1-6 inch soil depth.

In 1970, after the reestablishment of the bermudagrass, extractable Ca was thoroughly mixed into the top six inches of the soil. There was very little difference found between the extractable Ca in the 0-1 inch soil depth and the 1-6 inch depth. However, in 1971, the extractable Ca decreased in the top inch of soil, but increased at the 1-6 inch soil depth as compared with the previous year.

The Mg status of Bowie fine sandy loam soil following annual applications of P is shown in Table 12. At the initiation of the experiment the soil contained 92 ppm of extractable Mg. As was shown with Ca, the Mg content of the soil was also not directly affected by annual applications of P regardless of soil depth.

In 1966, the extractable Mg at both soil depths was lower than the

Table 10.-The K status of Bowie fine sandy loam soil following annual applications of P.

P	1966		1967		1968		1969[1/]	1970		1971	
	Depth		Depth		Depth		Depth	Depth		Depth	
applied annually	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-5 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.
lbs/acre	-------------------------------------Extractable K , ppm-------------------------------------										
0	129	118	103	84	137	130	103	232	174	179	172
13	117	109	85	39	109	94	87	208	147	149	114
26	119	98	81	46	94	68	79	204	136	146	104
39	112	97	81	38	91	63	78	208	129	128	91
52	115	98	80	39	82	62	79	293	127	125	95
66	104	78	79	35	84	52	80	193	114	168	88

[1/] Experimental area was renovated in 1969.

Table 11.-The Ca status of Bowie fine sandy loam soil following annual applications of P.

P applied annually	1966 Depth 0-1 in.	1966 Depth 1-6 in.	1967 Depth 0-1 in.	1967 Depth 1-6 in.	1968 Depth 0-1 in.	1968 Depth 1-6 in.	1969[1/] Depth 0-5 in.	1970 Depth 0-1 in.	1970 Depth 1-6 in.	1971 Depth 0-1 in.	1971 Depth 1-6 in.
lbs/acre	-----------------	-----------------	-----------------	-----------------	-----Extractable Ca, ppm-----	-----------------	-----------------	-----------------	-----------------	-----------------	-----------------
0	468	490	180	253	2058	262	698	987	990	787	1040
13	392	519	213	353	1748	303	802	942	902	1027	1080
26	532	540	207	487	2253	368	742	972	925	927	1140
39	535	505	187	367	2118	333	825	998	977	840	1013
52	517	510	213	347	1590	232	790	927	872	953	1007
66	548	542	240	427	1085	312	752	883	828	713	1000

[1/] Experimental area was renovated in 1969.

Table 12.-The Mg status of Bowie fine sandy loam soil following annual applications of P.

P applied annually	1966		1967		1968		1969[1/]	1970		1971	
	Depth		Depth		Depth		Depth	Depth		Depth	
	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-5 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.
lbs/acre	------------------------------Extractable Mg, ppm------------------------------										
0	63	57	29	17	168	22	189	162	165	128	200
13	59	61	29	21	152	32	217	149	162	127	167
26	62	62	33	17	187	29	189	140	157	111	183
39	73	67	37	29	203	30	203	166	165	131	168
52	65	64	38	30	157	24	212	190	145	162	187
66	68	68	45	28	194	28	214	165	132	129	217

[1/] Experimental area was renovated in 1969.

initial Mg content of the soil. There was a further decrease in the Mg content of the soil from all P treatments in 1967. This result was probably due to the large applications of ammonium nitrate to the bermudagrass, along with the increased forage yields.

In 1968, soil samples from all treatments showed a large increase in extractable Mg at the 0-1 inch soil depth. This increase in Mg resulted from the surface application of dolomitic limestone. However, there was very little change in the Mg content of the soil at the 1-6 inch depth due to the application of the dolomitic limestone.

During the renovation and reestablishment of the bermudagrass, the Mg in the top inch of soil was mixed deeper into the soil. The content of extractable Mg was much greater after renovation in the 1-6 inch soil depth than during any of the previous years at this depth.

The Mg content of the soil samples taken in 1971 decreased at the 0-1 inch depth as compared with the previous year. This was probably due to the further application of ammonium nitrate as a topdressing. However, the extractable Mg at the 1-6 inch soil depth increased in 1971 as compared with the Mg content in the previous year.

The Mg status of this Bowie soil during the investigation was very similar to the Ca status of the soil. Both elements were influenced primarily by the application of ammonium nitrate and dolomitic limestone to the bermudagrass.

The pH of Bowie fine sandy loam soil following annual applications of P is shown in Table 13. The initial pH of the soil was 5.8. Prior to the establishment of common bermudagrass, two tons of dolomitic limestone per acre were applied to the soil. The pH of the soil was not directly affected during the investigation by annual applications of P.

In 1966, after the first year of bermudagrass harvests, the soil reaction at the 0-1 inch depth was slightly higher than the original pH of 5.8. At the 1-6 inch depth, the pH was higher than the pH at the 0-1 inch depth after the first year of harvests. After the second year of forage production, there was a considerable decrease in the soil pH, especially at the 0-1 inch depth. In 1967, the soil pH in the 0-1 inch depth was approximately 4.4, while the pH was about 5.3 at the 1-6 inch soil depth. This rapid decrease in pH was due to the heavy topdressings of ammonium nitrate on the bermudagrass.

During 1967, one ton of dolomitic limestone per acre was applied to the bermudagrass as a surface application. In the following year, 1968, the pH at the 0-1 inch depth increased to 6.0 or above in all of the P treatments. However, the pH of the soil at the 1-6 inch depth showed a much smaller increase than at the 0-1 inch depth. The average pH of the soil at the 1-6 inch depth was 5.6 in 1968.

In 1970, after reestablishment of the bermudagrass, the pH of the soil at both depths increased over that of 1968. The pH at the 0-1 inch soil depth averaged 6.5, while the pH at the 1-6 inch depth was approximately 6.6 for all the P treatments. However, in 1971, the pH in the 0-1 inch depth decreased again, and the pH of the soil at the 1-6 inch

Table 13.-The pH status of Bowie fine sandy loam soil following annual applications of P.

P applied annually	1966		1967		1968		1969[1/]	1970		1971	
	Depth		Depth		Depth		Depth	Depth		Depth	
	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.	0-5 in.	0-1 in.	1-6 in.	0-1 in.	1-6 in.
lbs/acre	--pH--										
0	5.7	5.9	4.3	5.1	6.0	5.3	6.4	6.4	6.5	6.1	6.8
13	5.8	6.1	4.3	5.3	6.0	5.4	6.4	6.5	6.7	6.1	6.8
26	6.0	6.1	4.4	5.4	6.3	5.7	6.4	6.6	6.6	6.2	6.8
39	6.0	6.2	4.6	5.4	6.3	5.8	6.5	6.5	6.7	6.1	6.8
52	5.9	6.1	4.3	5.4	6.2	5.7	6.5	6.6	6.6	6.2	6.8
66	6.1	6.2	4.4	5.4	6.4	5.7	6.5	6.5	6.6	6.3	6.8

[1/] Experimental area was renovated in 1969.

depth showed a small increase up to 6.8. The decrease in pH at the 0-1 inch depth occurred as a result of the nitrogen topdressings applied to the bermudagrass.

The relationship between applied P and the yield of common bermudagrass grown on Bowie fine sandy loam is shown in Figure 6. A highly significant simple correlation ($r = 0.533$) was found between these two variables. The regression equation indicated that a linear relationship existed between yield and applied P.

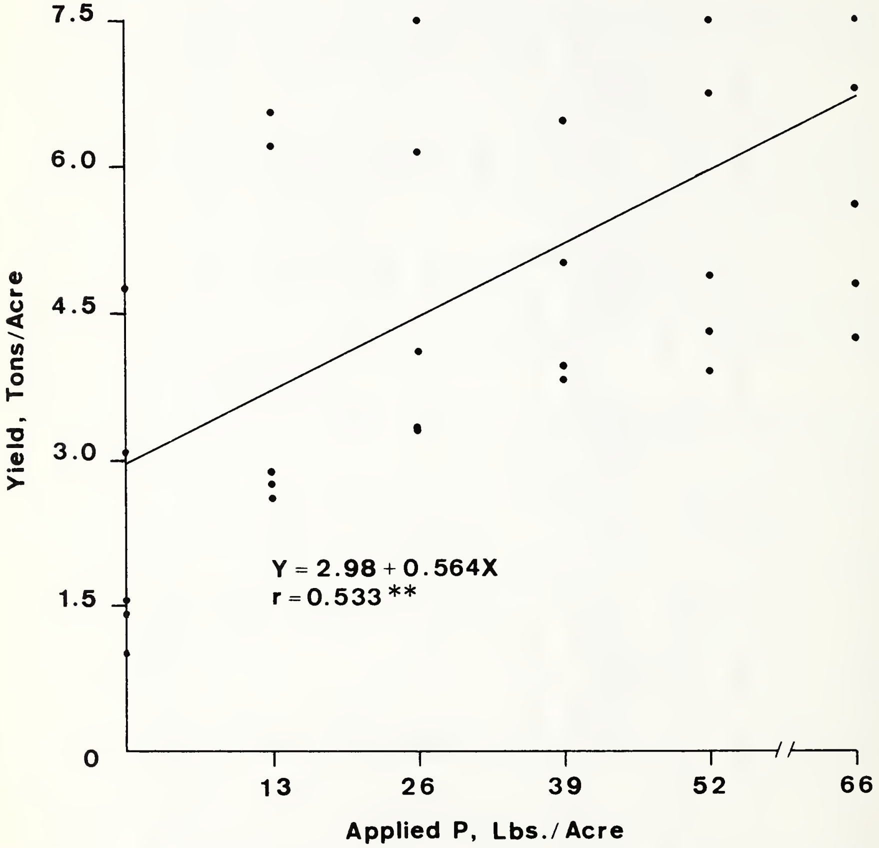

Fig. 6—The relationship between applied P and the yield of common bermudagrass grown on Bowie fine sandy loam.

The relationship between annual applications of P and the P content of common bermudagrass tissue is shown in Figure 7. A highly significant simple correlation (r = 0.938) was found between these two variables. The data show that when no P was applied to the Bowie soil the P content of the grass was critically low. Each increment of applied P resulted in a consistent and significant increase in the concentration of P in the tissue. The regression analysis indicated a positive curvilinear relationship between P content in the grass tissue and applied P.

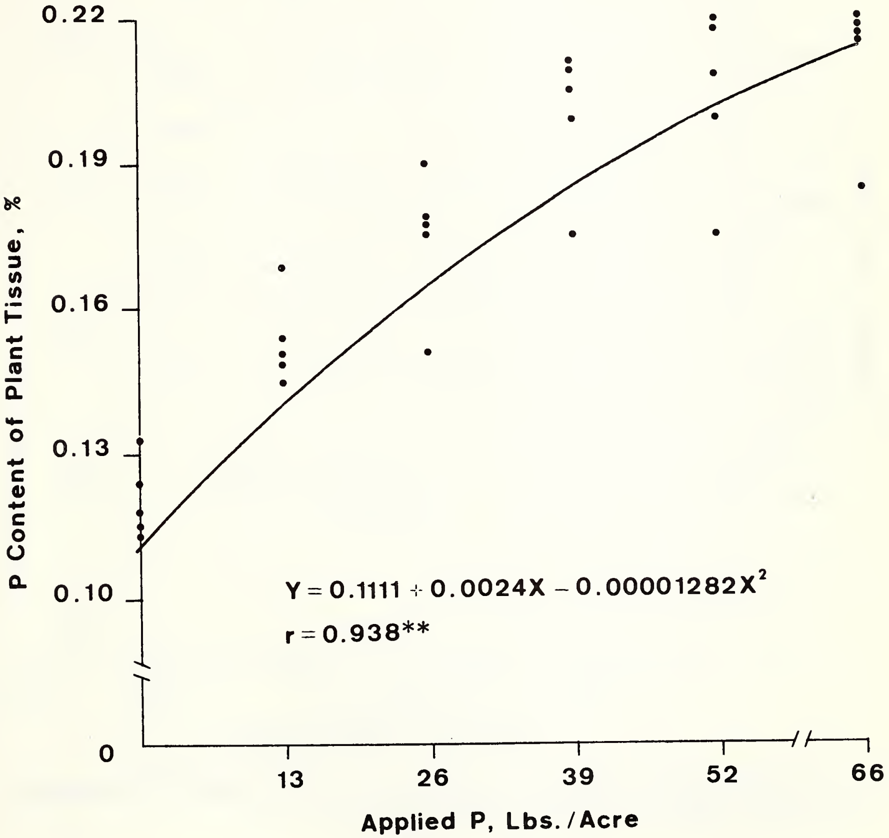

Fig. 7—The relationship between annual application of P and the P content of common bermudagrass tissue.

The influence of annual applications of P on the P uptake by common bermudagrass on Bowie fine sandy loam is shown in Figure 8. A highly significant relationship (r = 0.675) was obtained between these two variables. The regression equation indicated that a linear relationship existed between the uptake of P and applied P.

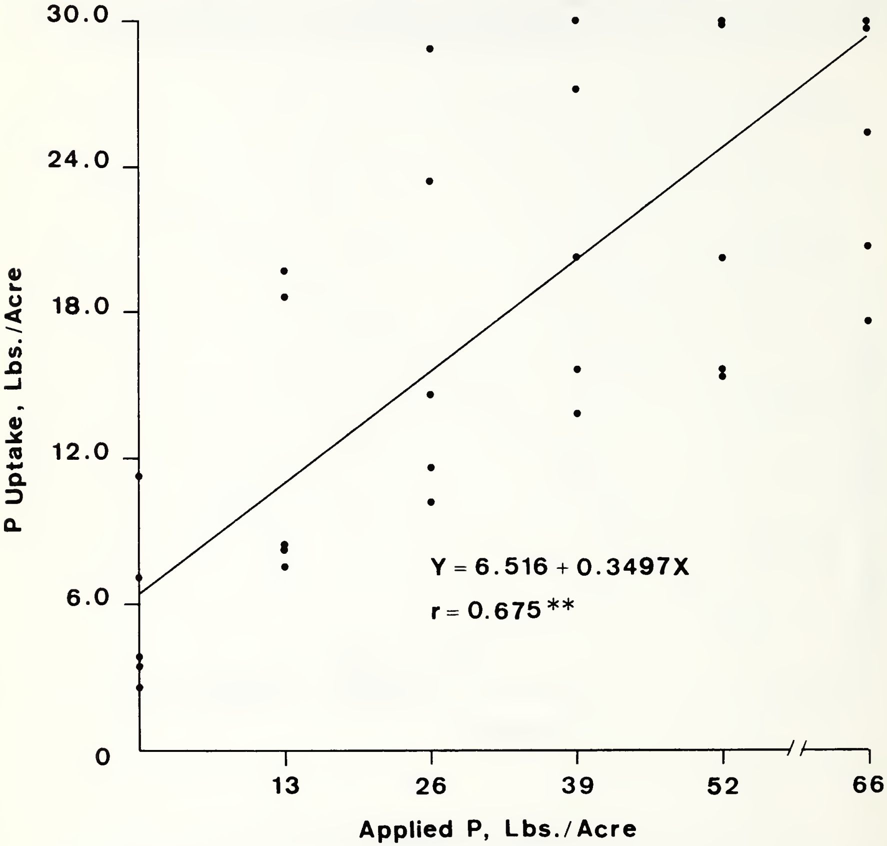

Fig. 8—The influence of annual application of P on P uptake by common bermudagrass grown on Bowie fine sandy loam.

The P content of Bowie fine sandy loam each year following annual applications of P is shown in Figure 9. Significant positive correlations were found each year between the P content of the soil and P treatments. Regression equations showed a curvilinear relationship between the P content of the soil and applied P each year of the investigation. The data show that each increment of applied P resulted in a buildup of P in the soil over the duration of the experiment. A relatively high buildup of soil P resulted from the annual application of 39, 52 and 66 pounds of P, respectively.

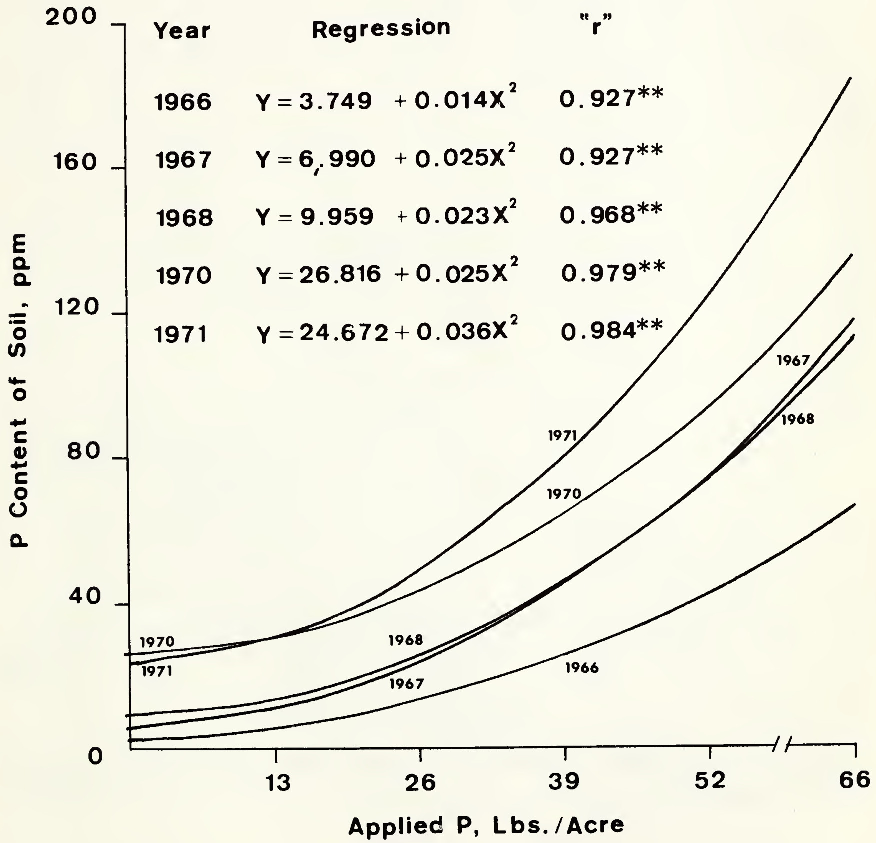

Fig. 9—The P content of Bowie fine sandy loam following each annual application of P.

Phosphorus content of Bowie fine sandy loam following six annual applications of P is shown in Figure 10. A highly significant relationship (r = 0.959) was found between these two variables. The regression equation indicated a curvilinear relationship existed between the P content of the soil and applied P.

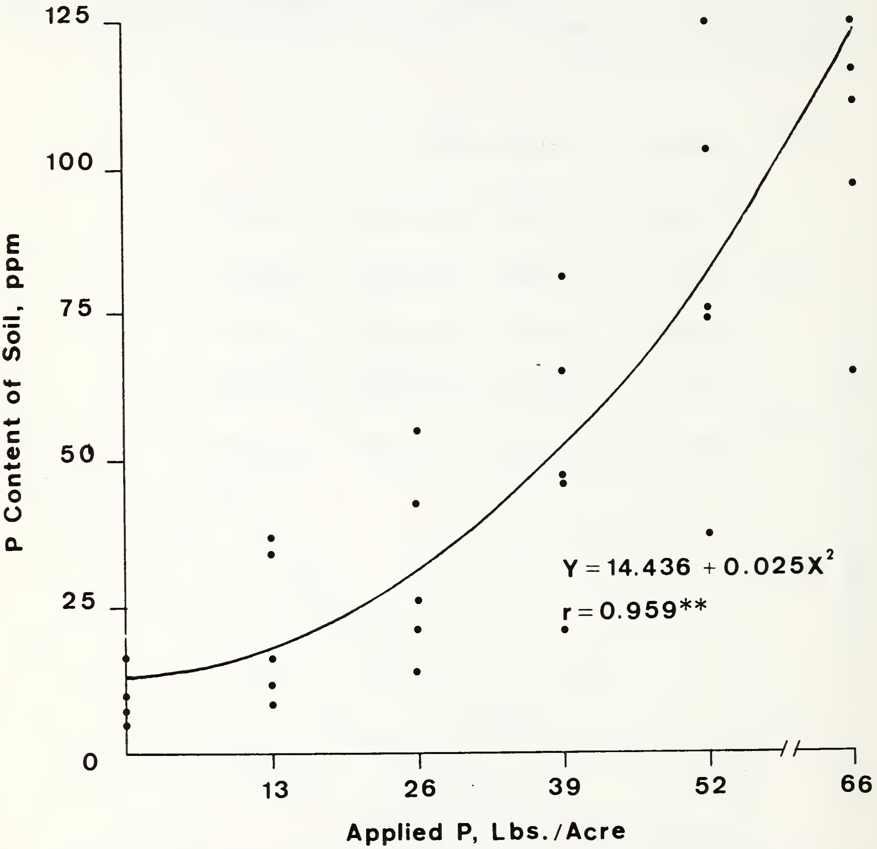

Fig. 10—The P content of Bowie fine sandy loam following six annual applications of P.

SUMMARY AND CONCLUSIONS

An investigation was conducted on a Bowie fine sandy loam soil to determine the effects of annual applications of P on the yield and chemical composition of common bermudagrass. A second objective of this study was to relate the annual applications of P to the P content of the soil and to forage yield. This investigation was conducted as part of Regional Project S-52.

Significant differences in the forage yield of common bermudagrass were obtained each year among levels of applied P. The highest forage yields each year occurred at the highest rates of applied P. The regression equation indicated that a linear relationship existed between applied P and forage yield. Phosphorus content of the forage increased each year with each increment of applied P. The regression analysis indicated a positive curvilinear relationship between P content in the grass tissue and applied P.

In general, as the rates of P increased, the percentage recovery of the applied P by bermudagrass decreased each year. In most years of the investigation, the highest percentage recovery of the applied P was obtained with an annual application of 13 pounds of P per acre. The recovery of applied P tended to increase or decrease in relation to forage yield.

As the amount of applied P per acre increased, there was a reduction in the yield of bermudagrass per pound of applied P. The yield response of bermudagrass to the applied P decreased as the extractable P increased in the 0-1 inch soil depth. The P uptake from the soil increased each year with each increment of applied P.

With continued annual applications of P, a buildup of extractable P occurred in the top inch of soil at all rates of applied P. Regression equations showed a positive curvilinear relationship between the extractable P in the soil and applied P each year of the investigation. The buildup of P in the 0-1 inch soil depth was much greater at the higher rates of applied P. However, there was a decrease in the P content of the soil at the 1-6 inch soil depth, regardless of the rates of applied P. It is apparent that common bermudagrass removed a considerable amount of P from the 1-6 inch soil depth. Renovation was necessary in order to increase the extractable P at the 1-6 inch soil depth.

The percent K in the bermudagrass forage and the K uptake from the soil were variable from year to year and apparently were not directly affected by annual applications of P. Each year of the investigation, the K content of the soil was considerably higher at the 0-1 inch soil depth than at the 1-6 inch soil depth regardless of the rate of applied P. There was no buildup of extractable K in the soil at either of the soil depths. Apparently, annual applications of P to bermudagrass had no direct effect on the K status of the soil. The extractable K in the soil varied each year in relation to forage production.

Neither the Ca content nor the Mg content of bermudagrass was affected by rates of applied P. In general, the Ca and Mg uptakes varied in relation to the yield of bermudagrass forage. The Ca, Mg and pH statuses of the soil were not directly affected during the investigation by annual applications of P. These properties were influenced primarily by the application of ammonium nitrate and dolomitic limestone to the bermudagrass.

APPENDIX

Rainfall data at the West Louisiana Experiment Station, Rosepine, 1965-1970.1/

Month	1965	1966	1967	1969	1970	Average
January	5.20	6.95	1.68	1.56	1.79	3.44
February	3.11	10.67	4.14	7.60	2.88	5.68
March	3.37	1.26	4.77	5 04	3.43	3.57
April	1.07	4.70	5.10	6.11	4.06	4.21
May	4.80	2.50	4.79	4.61	3.83	4.11
June	1.60	2.92	3.91	1.58	1.38	2.28
July	2.31	3.81	4.71	3.63	6.42	4.18
August	2.41	8.33	3.96	1.64	5.76	4.42
September	8.39	3.18	3.38	0.74	4.29	4.00
October	0.81	5.16	3.09	2.95	8.86	4.17
November	4.01	6.14	4.20	1.88	2.34	3.71
December	7.18	3.88	6.37	8.68	3.67	5.96
Total	44.26	59.50	54.17	46.02	48.71	50.53

1/Rainfall for 1968 was not included because yield data were not obtained.

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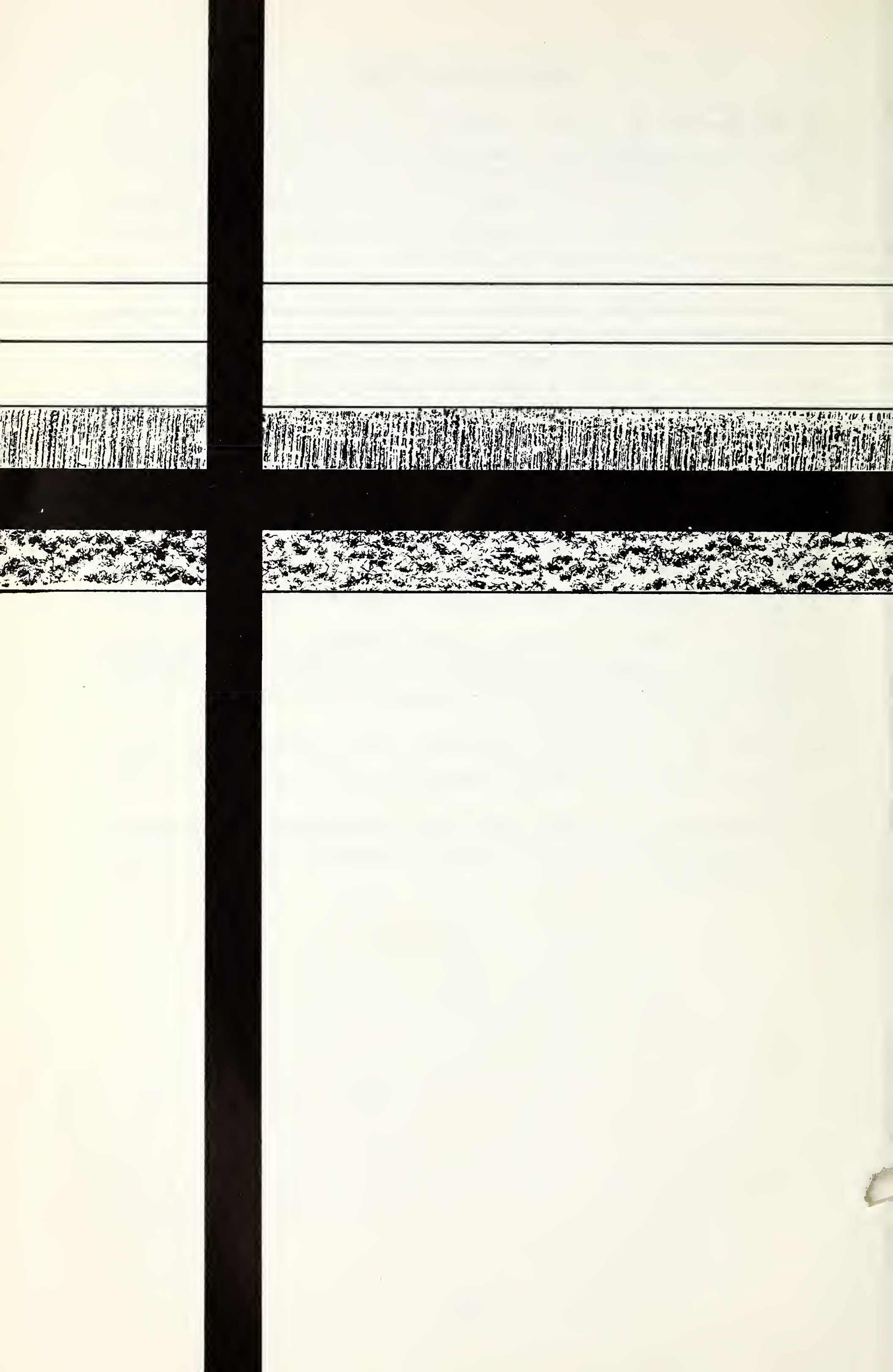

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The Effect of Sugarcane Production on Nutrient Contents of Mhoon and Jeanerette Silt Loams

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Special recognition is given to owners and managers of Little Texas Plantation and Alice "B" Plantation for providing facilities and personnel necessary for conducting field work and obtaining field data.

The Effect of Sugarcane Production On Nutrient Contents of Mhoon And Jeanerette Silt Loams

LARON E. GOLDEN[1]

INTRODUCTION

The amount of information available concerning the long-term effect of sugarcane production in Louisiana on nutrient contents of soils has been limited. Earlier work in Louisiana (*13, 14, 17, 18, 29*)[2] was concerned with total uptake of nutrients by sugarcane, the quantities removed from soils in millable cane and accompanying trash, and nitrogen (N) loss by burning cane in heap rows prior to hauling the cane to sugar factories.

Work previously conducted to determine the effect of sugarcane production on soil nutrients (*10*) was not accomplished over a sufficient period of time for trends to be established. Published data have often been incomplete since total amounts of the nutrient elements were not determined in soils under investigation and amounts removed in crops were not ascertained.

This study was made during the period 1959-1973, to determine the effect of a relatively common practice in Louisiana, fertilization of sugarcane with recommended rates of N, on macronutrient and organic carbon (C) contents of soils and on soil reaction (pH). The study was conducted on Mhoon silt loam and Jeanerette silt loam, two of the more important soil types on which cane is grown in Louisiana.

REVIEW OF LITERATURE

Salter et al. (*30*) reported losses in organic matter from unfertilized soil plots in Ohio after cropping to corn for 32 years. At the beginning of the period the soil contained 17.5 tons of organic matter, and at the end of the period it contained 6.4 tons of organic matter per acre.

In Louisiana, Tusneem and Patrick (*31*) presented data which showed large losses of total N from Crowley silt loam during successive cycles of submergence and drying. During a 120-day period the losses in total N were 14 to 16%, and well above 80% of the total loss occurred during the first two cycles, or within a period of 60 to 80 days.

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[1] Associate Professor, Department of Agronomy.

[2] Italic numbers in parentheses refer to Literature Cited, page 46.

Following five years of lysimeter studies, Jacobson et al. (*22*) reported that 95% of N leached from the soil was lost during the first six months after the fertilizer application. Willis (*34*), in Louisiana, reported that, from a six-year study on Richland silt loam, the N brought down to the soil in rainwater annually varied from 4.0 to 13.3 pounds and averaged 9.4 pounds per acre. The N losses by leaching varied from 2.0 to 95.4 pounds per acre per year. Losses were reduced by the presence of continuous cover.

Patrick et al. (*26*) found during a six-year study that even though 40 pounds of fertilizer N per acre applied to Commerce soil annually increased yield of cotton over that obtained from the check plots, the greater crop residue turned under had little effect in increasing or maintaining the soil's supply of organic matter. Wagner and Smith (*32*), in laboratory studies, stated that losses by volatilization of added fertilizer N may range up to 85% of the added N.

Haas et al. (*19*) made a study of the effect of cropping on the C and N contents of soil at 14 locations in the Great Plains. The period of cropping ranged from 30 to 43 years, and the N losses varied from 24 to 60%, with an average loss of 39%, over a 36-year period. Studies by Giddens (*9*) showed that the organic matter and N content of Georgia soils were rapidly reduced by cultivation. A 57% loss in organic matter occurred with 25 or more years of cultivation. The N content was reduced from 2,695 to 1,659 pounds per acre. Most of the organic C from a 20-ton application of easily decomposable organic matter was lost from a cultivated Cecil soil in 24 months.

Sulphur (S) is one of the elements essential for crop growth. Bonnet (*3*) found that S played an important role in sugarcane production in Puerto Rico. He observed that the application of 300 pounds of S per acre in S-deficient areas produced highly significant increases in yield of cane.

The "Soil" S was defined by Bardsley and Lancaster (*2*) as the combined organic, oxidizable inorganic and soluble sulphate S in soils. Golden (*12*), in a study of soils cropped to sugarcane in Louisiana, found that the "Soil" S content varied from 101 to 387 ppm in the A horizon and from 66 to 267 ppm in the B horizon. Soluble S varied from 3.1 to 20.4 ppm in the A horizon and from 2.9 to 36.2 ppm in the B horizon.

Ensminger (*8*) reported a study on the effect of SO_2 and other steam plant effluents on soils and plants in the Muscle Shoals area, Alabama, as a cooperative project with TVA. Results of the study showed that S brought down in rainwater in the Shoals area averaged 5 pounds per acre per year prior to operation of a steam electric power plant near Tuscumbia. Operation of the steam plant approximately doubled the amount of S in rainwater. He stated that sulfate is retained to a certain extent by most soils. Subsurface layers usually contain more sulfate and are capable of adsorbing more sulfate than surface layers. Light-textured soils usually do not contain sulfate or show a capacity to adsorb sulfate.

Byrnside and Sturgis (7), determined the total, organic and adsorbed phosphorus (P) in soils of the sugarcane area of Louisiana. They observed that a relatively higher percentage of the P is in organic form in soils low in total P, but the organic fraction apparently supplies relatively little available P.

Golden and Ricaud (*17*) concluded that the total amount of P in soils cropped to sugarcane in Louisiana is seriously low when compared with the rate of removal by the sugarcane crop. Even in the more fertile soils, P may become depleted to a critical degree within a few decades.

Golden (*12*) found from a study with several P extractants that correlation coefficients between data showing yield response to normal superphosphate and extractable P were generally low, due possibly to differences in the effect of the S in normal superphosphate on yield of sugarcane at the various locations.

Millar (*24*) reported that, although losses of P from the soil in drainage water seldom exceed 0.9 pound per acre annually, heavy losses of P occur through erosion because it is contained largely in the organic matter and smaller-sized soil particles. Working with seven loamy sand soils in Australia during a seven-year period, Ozanne et al. (*25*) found that the average loss of P in the top four inches of soil was 49% of the average amount of P applied, 146 pounds per acre. A further study of three of the soils indicated more loss of P from the next eight inches below the top four inches than was lost from the top four inches of soil.

During a long-term study at Lawton, Oklahoma, Haas et al. (*20*) observed that a period of 31 years of continuous row crops was associated with a decrease of 36% in the the total P content of the topsoil. The study further showed that losses of total P in soils of northern states due to cropping were less than losses in states farther south.

Ricaud (*28*) reported a highly significant negative relationship between potassium (K) extractable from the soil and response of sugarcane to fertilizer K. Golden and Ricaud (*16*) reported in 1967 that yields of sugarcane in Louisiana due to fertilizer N, P and K equalled 33.6% increase, or 25% of the total production. They observed that there was some depletion of available nutrients in the soil during the cycle of plant and stubble crops.

The calcium (Ca) and magnesium (Mg) contents of sugarcane and of soils in Louisiana on which sugarcane is grown were found to be substantially in excess of minimum amounts considered nutritionally necessary for good cane growth (*11*). There appeared to be no detrimental effect or imbalance of nutrient uptake by sugarcane created by high amounts of Ca and Mg in Louisiana soils.

Joshi and Zende (*23*) reported results from a long-term experiment in India on the effects of 337 kilograms of N per hectare on sugarcane in different combinations of organic and inorganic forms in the presence and absence of compost. They found that there was a small but consistent fall in pH in both the compost and no-compost series.

In a study of soil oxygen content and root development of sugarcane in six major soil types of the sugarcane producing areas of Louisiana, Patrick et al. (*27*) reported that in late September only a small amount of roots occurred at depths lower than 30 inches in the soil profile irrespective of oxygen content at those depths. In work related to yields of roots and below-ground stubble of sugarcane, Golden (*15*) found that 67, 28 and 5% of the roots obtained at harvest were contained in the soil profile at depths of 0-6, 6-12 and 12-24 inches, respectively. In a different study (*13*), data concerning rates of uptake of fertilizer P by sugarcane from 6-, 12- and 18-inch depths indicated that, early in the growing season, roots developed vertically in greater number and activity than they did laterally, but by the latter part of July the amounts of fertilizer P uptake from the three depths were approximately equal.

MATERIALS AND METHODS

Soils Sampled

Soil samples collected for analysis in this study were obtained from a Mhoon silt loam on Little Texas Plantation in Assumption Parish and a Jeanerette silt loam on Alice "B" Plantation in St. Mary Parish. Soils of the Mhoon and Jeanerette series have been classed as Recent Mississippi River alluvium. Soils of the Mhoon series occupy level to nearly level areas generally adjacent to the Mississippi River and Bayou Lafourche. Soils of the Jeanerette series occupy level to the nearly level areas on low terraces generally in the vicinity of Bayou Teche.

Topsoil samples were obtained at each location from a depth of 4-8 inches from the average level of the row ridge along a 20-foot segment of row in early spring, at midseason and at harvest, or at intervals of about four months, during each of 10 years when sugarcane was grown. Sampling of the Mhoon topsoil occurred from 1960 to 1973, and sampling of the Jeanerette topsoil occurred from 1959 to 1972. Since fertilizer N was placed in bands approximately 30 inches apart on each side of the row, probes with the sampling tool were restricted to an area that did not extend more than 8-10 inches laterally from the row line. At each location, sampling was initiated when a fertilizer experiment was also initiated on the area. Measurements from permanent ditches to the sampling sites were made in order that sampling during cycles of crops following fallow years could be accomplished at sites previously sampled. The location

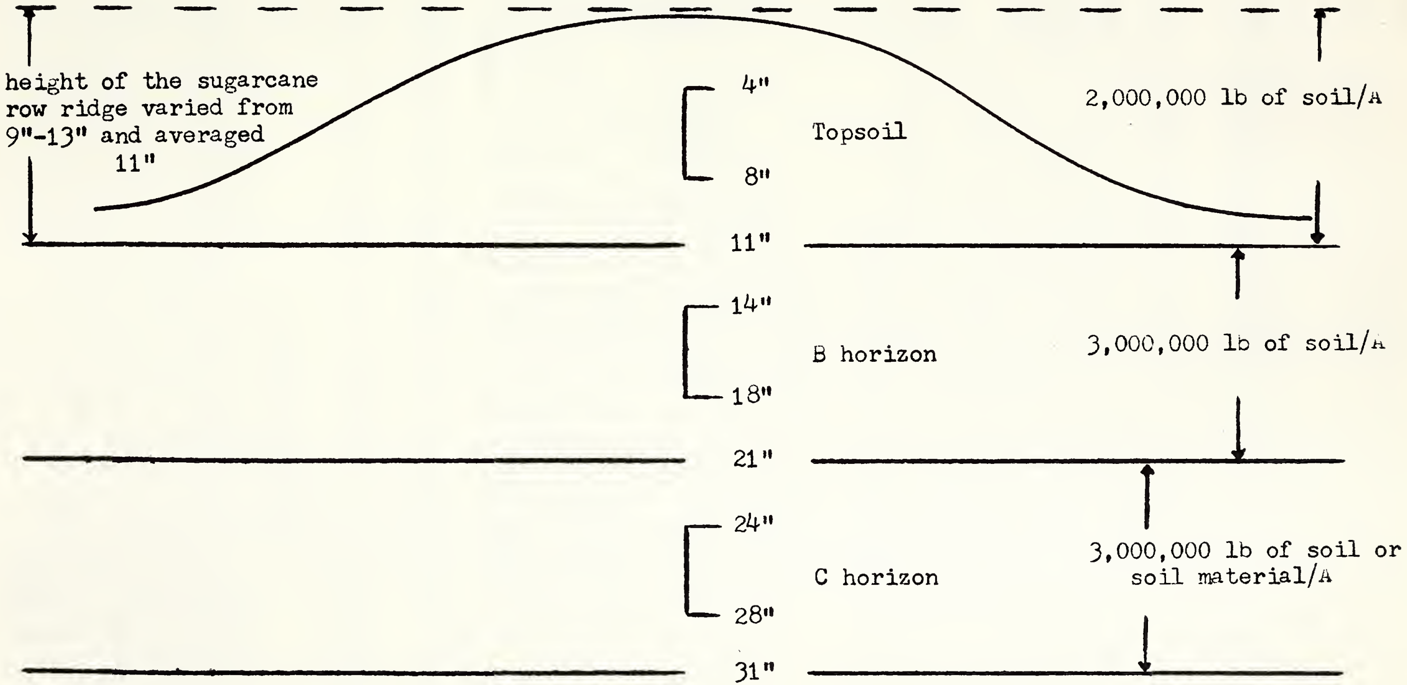
height of the sugarcane row ridge varied from 9"-13" and averaged 11"
4"
8"
Topsoil
2,000,000 lb of soil/A
11"
14"
18"
B horizon
3,000,000 lb of soil/A
21"
24"
28"
C horizon
3,000,000 lb of soil or soil material/A
31"

Figure 1. Diagram of soil profile showing the three horizons sampled.

of rows never varied laterally more than three feet from row locations in previous cycles of crops. The 20-foot segment of row from which samples were obtained at each site was located with the nearer end 15 feet from a quarter drain.

Soil samples were also obtained from each site from depths of 14-18 inches and 24-28 inches from the row ridge. At these lower depths, samples were taken during a period of about eight months at the beginning and at the end of the study.

A diagram of the soil profile showing the three horizons is shown in Figure 1. The row ridge at each location varied from about 9 to 13 inches in height above the middles. It was considered that samples from the 4-8-inch depth represented about 2,000,000 pounds of topsoil, the samples from the 14-18-inch depth represented about 3,000,000 pounds of B-horizon soil, and the samples from the 24-28-inch depth represented about 3,000,000 pounds of C-horizon soil or soil material.

Tables 1 and 2 show topsoil sample number, year, variety, age of cane, sampling period, N applied and yield of cane grown on Mhoon and Jeanerette silt loam soils. Table 3 shows soil sample number and sampling period in B and C horizons of both soil types.

Soil Analysis Procedures

Organic C was determined by the Walkley-Black (*33*) "wet-combustion" method, and total N was determined according to the modified method of Bremner (*5*). "Soil" S was determined by the method of Bardsley and Lancaster (*2*), and extractable S values were obtained by use of the method of Bardsley and Lancaster modified to extract larger quantities of sulphate S (*1*).

The soil samples were analyzed for total P, K, Ca and Mg according to a modification of the method of Jackson (*21*). Extractable P was determined by using modified Bray 1 and modified Bray 2 methods (*4*). Extractable K, Ca and Mg were determined by the method of Brupbacher et al. (*6*).

Solutions used for extracting P, K, Ca, Mg and S were maintained at 25°C (*10*).

The pH values from the soil samples were obtained by use of a Beckman Zeromatic pH meter.

Statistical Analyses

Statistical analyses were used to obtain correlation coefficients and regression equations for the relationships between topsoil sampling periods, or sequential periods from the beginning to the end of the study, and soil chemical properties of the Mhoon and Jeanerette soils. Correlation coefficients among soil chemical properties of both topsoils were also obtained. The means and the least significant differences (LSD) of the chemical properties were calculated for the B and C horizons of both soil types.

Table 1. Topsoil sample number, sampling period, fertilization and yield of cane on Mhoon silt loam.

Topsoil sample no.	Year	Variety	Class (age) of cane	Sampling period	N[1] applied lb/A	Yield Net tons/A
1	1960	CP52-68	Plant	Early spring	80	33
2				Midseason		
3				At harvest		
4	1961	CP52-68	First stubble	Early spring	120	30
5				Midseason		
6				At harvest		
7	1962	CP52-68	Second stubble	Early spring	120	17
8				Midseason		
9				At harvest		
10	1964	CP52-68	Plant	Early spring	120	35
11				Midseason		
12				At harvest		
13	1965	CP52-68	First stubble	Early spring	160	31
14				Midseason		
15				At harvest		
16	1966	CP52-68	Second stubble	Early spring	160	26
17				Midseason		
18				At harvest		
19	1968	CP52-68	Plant	Early spring	120	29
20				Midseason		
21				At harvest		
22	1969	CP52-68	First stubble	Early spring	160	27
23				Midseason		
24				At harvest		
25	1971	CP48-103	Plant	Early spring	120	29
26				Midseason		
27				At harvest		
28	1972	CP48-103	First stubble	Early spring	160	30
29				Midseason		
30				At harvest		

---

[1] Sources: 1960-62, ammonium nitrate; 1964-72, aqua ammonia.

Table 2. Topsoil sample number, sampling period, fertilization and yield of cane on Jeanerette silt loam.

Topsoil sample no.	Year	Variety	Class (age) of cane	Sampling period	N[1] applied	Yield
					lb/A	Net tons/A
31	1959	NCo310	Plant	Early spring	80	32
32				Midseason		
33				At harvest		
34	1960	NCo310	First stubble	Early spring	120	27
35				Midseason		
36				At harvest		
37	1961	NCo310	Second stubble	Early spring	120	27
38				Midseason		
39				At harvest		
40	1963	CP36-105	Plant	Early spring	120	35
41				Midseason		
42				At harvest		
43	1964	CP36-105	First stubble	Early spring	160	31
44				Midseason		
45				At harvest		
46	1965	CP36-105	Second stubble	Early spring	160	32
47				Midseason		
48				At harvest		
49	1967	CP52-68	Plant	Early spring	120	29
50				Midseason		
51				At harvest		
52	1968	CP52-68	First stubble	Early spring	160	28
53				Midseason		
54				At harvest		
55	1970	CP52-68	Plant	Early spring	120	27
56				Midseason		
57				At harvest		
58	1971	CP52-68	First stubble	Early spring	160	26
59				Midseason		
60				At harvest		

---

[1] Sources: 1959-60, ammonium nitrate; 1961-71, anhydrous ammonia.

Table 3. Soil sample number and sampling period in B and C horizons of Mhoon and Jeanerette silt loam soils.

Sample no.				Sample no.			
B hor.	C hor.	Year	Sampling period	B hor.	C hor.	Year	Sampling period
			Mhoon silt loam				
61	70	1960	Early spring	97	106	1972	Midseason
62	71	1960	Early spring	98	107	1972	Midseason
63	72	1960	Early spring	99	108	1972	Midseason
64	73	1960	Midseason	100	109	1972	At harvest
65	74	1960	Midseason	101	110	1972	At harvest
66	75	1960	Midseason	102	111	1972	At harvest
67	76	1960	At harvest	103	112	1973	Early spring
68	77	1960	At harvest	104	113	1973	Early spring
69	78	1960	At harvest	105	114	1973	Early spring
			Jeanerette silt loam				
79	88	1959	Early spring	115	124	1972	Midseason
80	89	1959	Early spring	116	125	1972	Midseason
81	90	1959	Early spring	117	126	1972	Midseason
82	91	1959	Midseason	118	127	1972	At harvest
83	92	1959	Midseason	119	128	1972	At harvest
84	93	1959	Midseason	120	129	1972	At harvest
85	94	1959	At harvest	121	130	1973	Early spring
86	95	1959	At harvest	122	131	1973	Early spring
87	96	1959	At harvest	123	132	1973	Early spring

RESULTS AND DISCUSSION

Results of chemical analyses of samples collected from the Mhoon and Jeanerette soils and statistical information obtained from the data are summarized in Tables 4 through 9 and in Figures 2 through 7. Tables 10 through 17, in the Appendix, contain detailed results obtained from chemical analysis of individual samples. In Figures 2 through 7, sampling periods 1, 4, 7, 10, 13, 16, 19, 22, 25 and 28 were in early spring, sampling periods 2, 5, 8, 11, 14, 17, 20, 23, 26 and 29 were at midseason and sampling periods 3, 6, 9, 12, 15, 18, 21, 24, 27 and 30 were at harvest.

Organic C, Total N and C/N Ratio

Organic C and total N contents of both soils generally decreased during the period of observation (Figure 2). The correlation coefficients between sampling period and organic C and between sampling period and total N in each soil were highly significant.

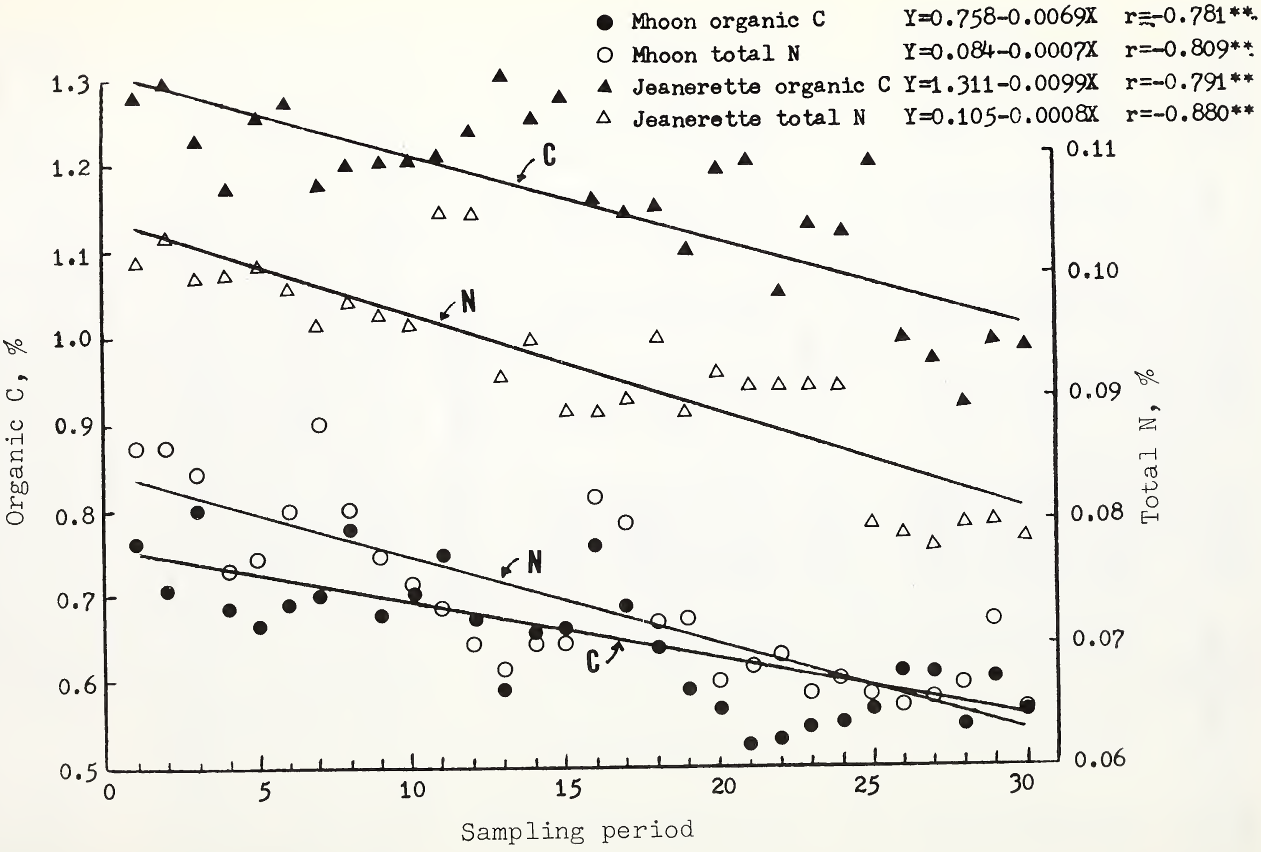

Figure 2. The relationship of sampling period to organic C and total N in Mhoon and Jeanerette topsoil.

Organic C

Calculations from regression equations (Tables 4 and 5) showed an absolute decrease of 0.207% organic C in Mhoon topsoil and an absolute decrease of 0.297% organic C in Jeanerette topsoil during the 13-year period. The relative decreases were 27% in the Mhoon topsoil and 23% in the Jeanerette topsoil.

In Table 6, it may be seen that organic C in the B horizon of the Mhoon soil increased from 0.432 to 0.505%. The difference approached statistical significance. Data from the C horizon revealed an increase in organic C, from 0.309 to 0.408%, which was statistically significant. With the topsoil, B horizon and C horizon samples representing 2,000,000, 3,000,000 and 3,000,000 pounds of soil or soil material per acre, respectively, calculations showed a net increase of 1,020 pounds per acre in organic C content, which equated to an average increase of 2.7% organic C in the three Mhoon horizons.

At the end of the study, organic C contents of the B and C horizons in the Jeanerette soil were statistically lower than at the beginning of the study (Table 6). Calculations indicated losses of 5,940 pounds of organic C per acre from the topsoil, 6,780 pounds per acre from the B horizon and 480 pounds per acre from the C horizon, or a total loss of 13,200 pounds per acre, which was equivalent to a 20% loss of organic C from the three Jeanerette soil horizons.

When considering comparable horizons, data in Tables 4, 5 and 6 show that organic C was higher in the Jeanerette soil than in the Mhoon soil. The organic C content of the three horizons of the Mhoon soil changed only in profile distribution and very little in average amount. In the Jeanerette soil, the general constancy at a low level normally expected for organic C content of soils row cropped continuously did not occur, probably due to the relatively high initial organic C content.

Total N

The regression equations (Table 4 and 5) indicated an absolute decrease of 0.021% total N in Mhoon topsoil and an absolute decrease of 0.024% total N in Jeanerette topsoil. The relative decreases were 25% in the Mhoon topsoil and 23% in the Jeanerette topsoil.

The total yield of sugarcane for the 10 crops on the Mhoon soil was 287 tons per acre. The average amount of total N in sugarcane plants per ton of millable cane, 4.24 pounds, has been reported in Louisiana, and the amount of N leaving the fields in millable cane and trash and by means of N loss from normal burning was approximately 2.67 pounds per ton of millable cane (*17*). Calculations from these data show that the millable cane and trash and normal burning accounted for removal of approximately 766 pounds of N per acre from the Mhoon silt loam. The total amount of N added in fertilizer during the 10-crop years was 1,320 pounds per acre. Although approximately

Table 4. Correlation coefficients (r) and linear regression equations for the relationship between topsoil sampling periods (X) and soil chemical properties (Y) of Mhoon silt loam.

Soil variable	Correlation coefficients (r)	Linear regression equations
Organic C	-0.781**	$Y=0.758 - 0.0069X$
Total N	-0.809**	$Y=0.084 - 0.0007X$
C/N ratio	-0.238	$Y=9.1 - 0.0167X$
"Soil" S	-0.111	$Y=82 - 0.09X$
Ext. S	-0.395*	$Y=17 - 0.0841X$
N/"Soil" S ratio	-0.585**	$Y=10.2 - 0.0665X$
pH	-0.556**	$Y=6.1 - 0.0170X$
Total P	-0.920**	$Y=506 - 2.51X$
Ext. P (Modified Bray 1)	-0.810**	$Y=24 - 0.4016X$
Ext. P (Modified Bray 2)	-0.016	$Y=198 - 0.0116X$
Total K	0.203	$Y=1.79 + 0.0008X$
Ext. K	0.142	$Y=65 + 0.1380X$
Total Ca	-0.527**	$Y=0.441 - 0.0013X$
Ext. Ca	0.345	$Y=1446 + 3.18X$
Total Mg	0.612**	$Y=0.287 + 0.0011X$
Ext. Mg	0.713**	$Y=277 + 2.91X$

Table 5. Correlation coefficients (r) and linear regression equations for the relationship between topsoil sampling periods (X) and soil chemical properties (Y) of Jeanerette silt loam.

Soil variable	Correlation Coefficients (r)	Linear regression equations
Organic C	-0.791**	Y=1.311 - 0.0099X
Total N	-0.880**	Y=0.105 - 0.0008X
C/N ratio	0.025	Y=12.5 + 0.0014X
"Soil" S	-0.847**	Y=132 - 1.24X
Ext. S	-0.877**	Y=23 - 0.4160X
N/"Soil" S	0.375*	Y=7.9 + 0.0209X
pH	-0.394*	Y=7.0 - 0.0086X
Total P	-0.913**	Y=375 - 1.90X
Ext. P (Modified Bray 1)	-0.105	Y=20 - 0.0454X
Ext. P (Modified Bray 2)	-0.605**	Y=137 - 0.7604X
Total K	0.185	Y=1.66 + 0.0004X
Ext. K	-0.563*	Y=62 - 0.3237X
Total Ca	-0.475*	Y=0.520 - 0.0008X
Ext. Ca	-0.678**	Y=2558 - 13.19X
Total Mg	-0.854**	Y=0.309 - 0.0018X
Ext. Mg	-0.901**	Y=550 - 5.22X

554 more pounds of N were added in fertilizer than were removed from the field in millable cane and by burning, the regression equation (Table 4) showed 420 pounds per acre loss of N from the topsoil.

Mhoon samples from the B horizon indicated no statistically significant change in total N content, but a statistically significant increase was noted in the samples from the C horizon (Table 6). Since the samples from the C horizon represented approximately 3,000,000 pounds of soil, the absolute increase in total N at that depth, 0.009%, accounted for about 270 pounds increase in N per acre in that horizon. Further calculations with fertilizer data and with data from Mhoon topsoil and C horizon samples indicate an approximate loss of 1,470 pounds of soil and fertilizer N per acre during the 13 years of crops and fallowing. Since 766 pounds of N per acre were removed in millable cane and trash and by burning, 704 pounds of N per acre, or an average of 54 pounds of N per acre per year, were removed from the soil by other means. Notwithstanding gains and losses of N by various means, the average total N in the three Mhoon horizons decreased 3.1% during the study.

The total yield of sugarcane for the 10 crops on the Jeanerette soil was 294 tons per acre. Calculations similar to those used to approximate the N status in the Mhoon soil indicated that millable cane and trash and normal burning accounted for removal of about 785 pounds of N per acre from the Jeanerette soil. The total amount of N added in fertilizer to the Jeanerette soil during the 10 crop years was 1,320 pounds per acre; consequently, about 535 more pounds of N were added in fertilizer than were removed from the field in millable cane and by burning. Data indicating the N status of samples from the B and C horizons in the Jeanerette soil (Table 6) showed statistically lower amounts of total N in each horizon. Calculations with all N data from the Jeanerette experiment indicate a decrease of 2,220 pounds of soil and fertilizer N per acre during the 13 years of crops and fallowing. Since 785 pounds of N per acre were removed in millable cane and trash and by burning, 1,435 pounds of N per acre, or about 110 pounds of N per acre per year, were removed from the soil by other means. The average total N in the three Jeanerette horizons decreased 15%.

C/N ratio

The organic C and total N contents of topsoils at each location decreased approximately to the same degree; consequently, the C/N ratios did not vary significantly during the study (Tables 4 and 5). The C/N ratios in the Mhoon topsoil were generally lower than in the Jeanerette topsoil. It may be noted in Table 6 that the C/N ratios in the B horizon of the Mhoon soil and in the C horizon of the Jeanerette were statistically wider at the end than at the beginning of the experiments.

Table 6. Means of the organic C and total N contents, C/N ratios, "Soil" S and extractable S contents, and N/"Soil" S ratios of subsoil samples from Mhoon and Jeanerette silt loam soils.

Soil type	Sampling depth	Sampling period 1/	Organic C	Total N	C/N ratio	S "Soil"	S Ext.	N/"Soil" S ratio
	in.		%	%		ppm	ppm	
Mhoon sil	14-18	1	0.432	0.062	7.0	60	11	10.4
Mhoon sil	14-18	2	0.505	0.058	8.8	64	15	9.0
		LSD 0.05:	NS	NS	1.2	4	2	0.4
Mhoon sil	24-28	1	0.309	0.043	7.2	48	10	9.1
Mhoon sil	24-28	2	0.408	0.052	7.8	63	12	8.4
		LSD 0.05:	0.064	0.004	NS	9	2	NS
Jeanerette sil	14-18	1	0.846	0.069	12.3	78	12	8.8
Jeanerette sil	14-18	2	0.620	0.063	10.0	71	14	8.9
		LSD 0.05:	0.187	0.004	NS	5	1	NS
Jeanerette sil	24-28	1	0.500	0.058	8.7	64	14	9.0
Jeanerette sil	24-28	2	0.484	0.050	9.6	59	10	8.6
		LSD 0.05:	0.016	0.004	0.7	4	2	NS

1/ In the Mhoon silt loam, sampling periods 1 and 2 were in 1960 and in 1972-73, respectively. In the Jeanerette silt loam, sampling periods 1 and 2 were in 1959 and in 1972-73, respectively.

"Soil" S, Extractable S and N/"Soil" S Ratio

"Soil" S

It can be seen in Figure 3 that a highly significant relationship was found between "Soil" S in the topsoil and sampling period at each location. In the Mhoon soil, the linear relationship was not significant (Table 4), but the highly significant quadratic equation, derived from the data, indicated a general decrease in "Soil" S during the early part of the study and an increase from the lowest level during the latter part of the study. It may be noted that "Soil" S contents of the B and C horizons in the Mhoon soil (Table 6) were higher at the end of the study. Since no samples were taken from these horizons between the sampling periods in 1960 and 1972-73, it was not possible to determine when the increases occurred. The average "Soil" S in the three Mhoon horizons was 9.6% higher when the experiment ended. It appears that the increases in S content of the Mhoon soil were due to atmospheric release of S from relatively new plants and general industrial activity in the vicinity, primarily along the Mississippi River and Bayou Lafourche.

As illustrated in Figure 3, the "Soil" S in the Jeanerette topsoil generally decreased, and significantly lower amounts were also found in the B and C horizons at the end of the study (Table 6). The calculated decrease in the topsoil was 37 ppm, or 28%. With decreases of 37 ppm, or 74 pounds per acre, in Jeanerette topsoil, 7 ppm, or 21 pounds per acre, in the B horizon, and 5 ppm, or 15 pounds per acre, in the C horizon, the approximate loss from the Jeanerette soil from the three horizons was 110 pounds per acre, 8.5 pounds of S per acre per year, or 16%.

The S leaving Louisiana fields in millable cane and trash was reported at about 0.60 pound per ton of millable cane when the cane received fertilizer S (*18*). From four years of data (*14*), it was found that about 0.35 pound of S was contained in each ton of millable cane and trash when the cane received no fertilizer S. Since the production of cane in the Jeanerette soil during the 10-crop years was 294 tons, the amount of S leaving the field in millable cane and trash was about 103 pounds per acre during the study.

Since the loss of S from the Jeanerette soil (110 pounds) was about equal to the amount for which an accounting may be made due to the amount removed from the field in millable cane and trash (103 pounds), it was concluded that any gain in S from the atmosphere and other sources was approximately equal to the loss by runoff, through leaching to horizons below those sampled, and/or losses to the atmosphere due to burning of trash or by other means.

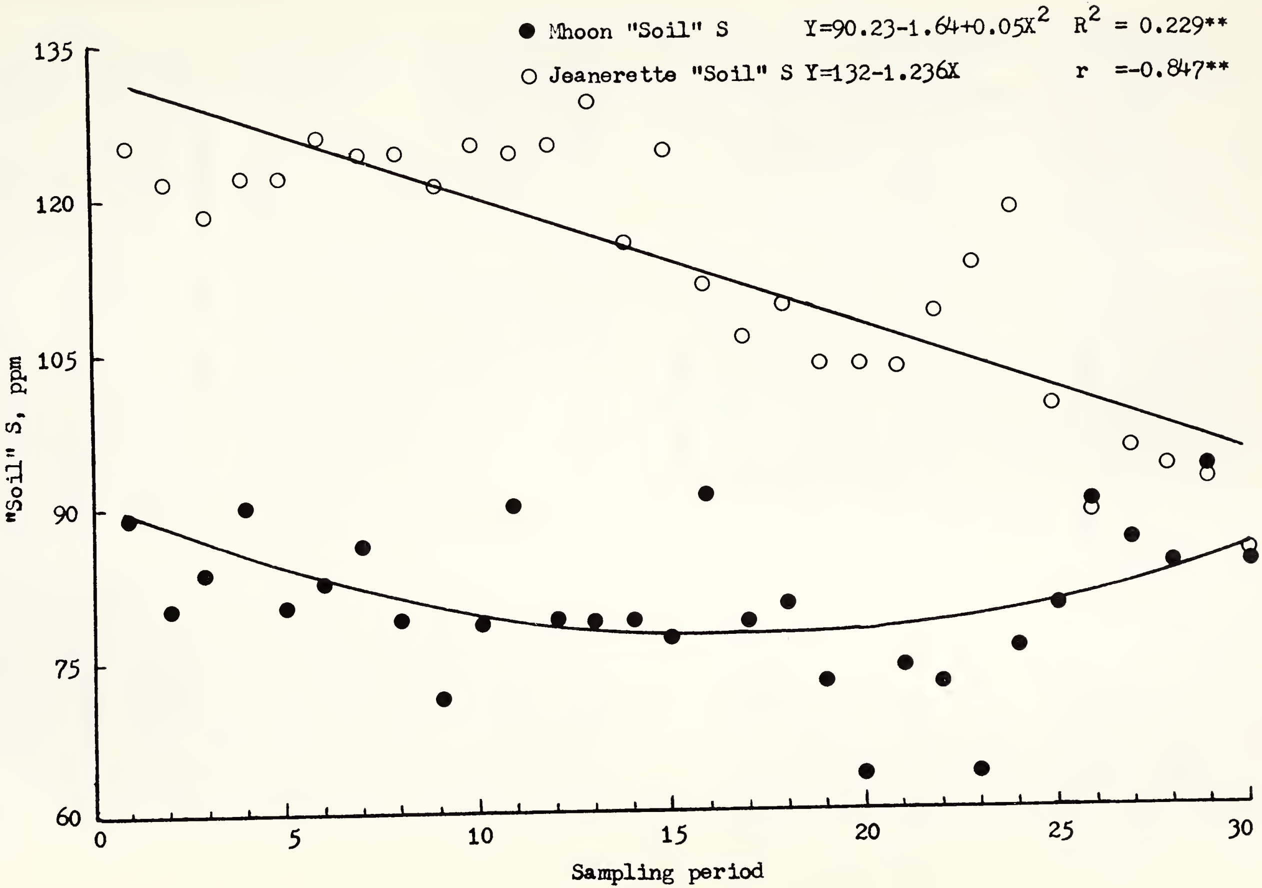

Figure 3. The relationship of sampling period to "Soil" S in Mhoon and Jeanerette topsoil.

Extractable S

In both Mhoon topsoil and Jeanerette topsoil, extractable S was negatively associated with sampling period (Tables 4 and 5 and Figure 4). At the end of the study, the S extractable from B and C horizons of the Mhoon soil was higher and was generally associated with the increase in "Soil" S. The B horizon of the Jeanerette soil contained a significantly higher amount of extractable S, but the C horizon contained a significantly lower amount of extractable S when the experiment ended (Table 6).

N/"Soil" S ratio

In Tables 4 and 5, it may be noted that there was a highly significant decrease in the N/"Soil" S ratio of the Mhoon topsoil and that a significant increase in the N/"Soil" S ratio occurred in the Jeanerette topsoil. In the Mhoon soil, the ratio narrowed significantly in the B horizon and the smaller ratio in the C horizon approached significance (Table 6). The smaller ratios in the three Mhoon horizons were due primarily to increases in S. The wider N/"Soil" S ratio in the Jeanerette topsoil was due to a greater relative loss of S than N.

Total and Extractable P

Total P

It can be seen in Figure 5 that total P in Mhoon topsoil and Jeanerette topsoil generally decreased throughout the study. Calculations using the regression equations (Tables 4 and 5) showed that the decreases were 75 ppm, or 150 pounds per acre, in Mhoon topsoil and 57 ppm, or 114 pounds per acre, in Jeanerette topsoil. Relative to the total P in the soils at the beginning of the study, the decreases were 15% in the Mhoon topsoil and 15% in the Jeanerette topsoil.

Data in Table 7 show that significant decreases in total P occurred in the B horizons of both soils and that differences in the C horizons were not statistically significant. The decrease in the B horizon of the Mhoon soil was 54 ppm, or 162 pounds per acre. The decrease in the B horizon of the Jeanerette soil was 43 ppm, or 129 pounds per acre.

The average amount of P leaving Louisiana fields in millable cane and trash was reported to be equivalent to about 1 pound of P_2O_5 per ton of millable cane (*17*). Considering P content and yield of cane, P equivalent to 287 pounds of P_2O_5 and 294 pounds of P_2O_5 was removed from the Mhoon and the Jeanerette soil, respectively.

The loss in total P from the Mhoon soil was equivalent to 716 pounds of P_2O_5 per acre from the topsoil and the B horizon. Similar calculations with data from Jeanerette soil indicated a loss in total P equivalent to 557 pounds of P_2O_5 per acre.

From these data it may be seen that the loss of P in the Mhoon soil

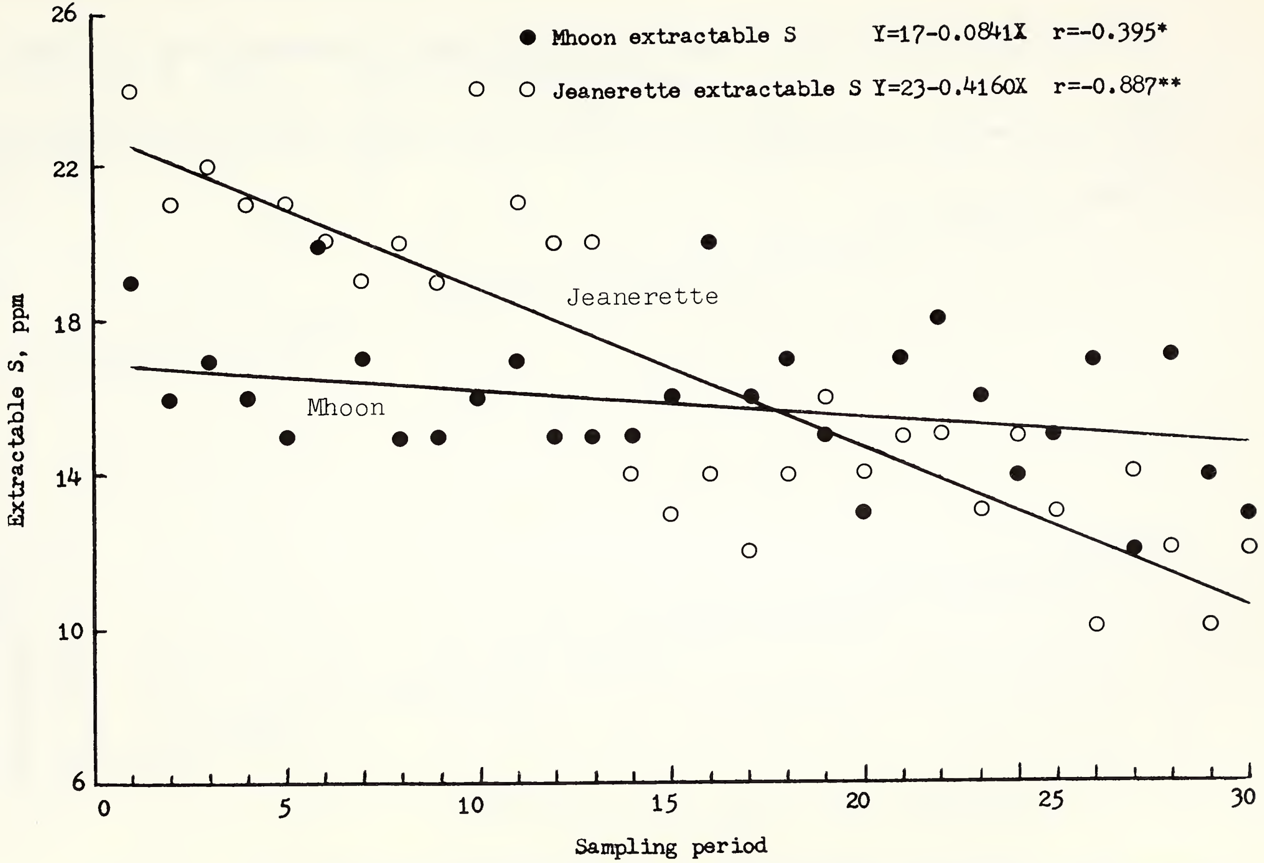

Figure 4. The relationship of sampling period to extractable S in Mhoon and Jeanerette topsoil.

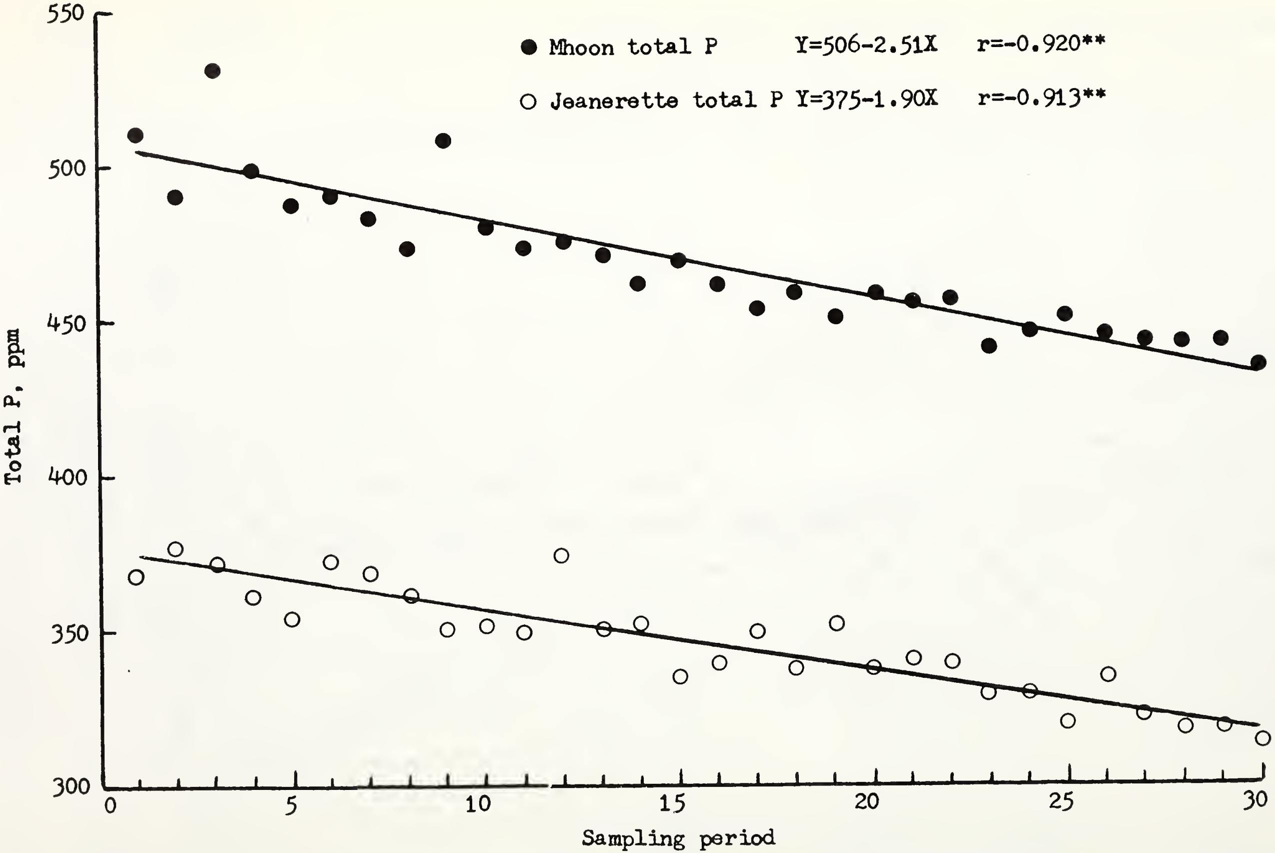

Figure 5. The relationship of sampling period to total P in Mhoon and Jeanerette topsoil.

by means other than in millable cane and trash was equivalent to 429 pounds of P_2O_5 per acre during the 13-year period, or an average of about 33 pounds per acre per year. The calculated loss from the Jeanerette soil by means other than in millable cane and trash was 263 pounds of P_2O_5 per acre, or 20 pounds per acre per year.

The average losses in total P from the three horizons were 7.5% in the Mhoon soil and 8.8% in the Jeanerette soil.

Very small quantities of P are normally lost from soils in drainage water, but heavy losses may occur through erosion since P is contained largely in organic matter and smaller-sized soil particles (*24*). It appears that most of the losses in P from the Mhoon and Jeanerette soils by means other than in millable cane and trash occurred as a result of wind and water erosion. The ash resulting from burning of cane trash during harvest contains substantial quantities of mineral elements and is susceptible to loss by both wind and water erosion. The analysis of P in runoff water from fields frequently is misleading in that it is accomplished by a rapid method designed to measure only ionic P and not the P in soluble and insoluble organic matter and smaller-sized soil particles transported in the runoff water.

The loss of P from each of the two soils was moderate when considering the three horizons as a unit, i.e., the growing medium for roots. The depletion rates of P in the topsoil and B horizons at each location, however, were relatively high and were generally proportional to the quantity of roots in those horizons. Application of P in the topsoil and upper portion of the B horizon at rates of P equivalent to 40 to 60 pounds of P_2O_5 per acre each crop year should be adequate to maintain the soil P at a constant level. Since the total P in soils cropped to sugarcane in Louisiana is low, lack of attention to maintenance of adequate levels of P in soils could result in a serious degradation in the general soil fertility status of the soils.

Extractable P

Results from work with Mhoon topsoil using the modified Bray 1 method showed a highly significant decrease in the extractable P during the sampling period but no significant relationship when the modified Bray 2 method was used (Table 4 and Figure 6).

The P in the Jeanerette topsoil extracted by the modified Bray 1 method was not significantly related to the sampling period. The P extracted by the modified Bray 2 method, however, was negatively related to the sampling period (Table 5).

Generally, the amounts of P extracted by the modified Bray 1 method from the B and C horizons in the Mhoon and the Jeanerette soils were too low to be of practical significance. It may be noted, however, that P extractable from the B and C horizons by the modified Bray 2 method was significantly lower at the end of the sampling period in both soils (Table 7).

Table 7. Means of total and extractable P, K, Ca and Mg contents of subsoil samples from Mhoon and Jeanerette silt loam soils.

Soil type	Sampling depth	Sampling period 1/	P			K		Ca		Mg	
			Total	Ext.1 2/	Ext.2 2/	Total	Ext.	Total	Ext.	Total	Ext.
	in.		ppm	ppm	ppm	%	ppm	%	ppm	%	ppm
Mhoon sil	14-18	1	516	9	231	1.97	102	0.377	2707	0.487	842
Mhoon sil	14-18	2	462	11	198	1.63	86	0.403	2360	0.367	558
		LSD 0.05:	16	1	11	0.06	9	0.019	158	0.029	39
Mhoon sil	24-28	1	525	8	280	1.80	80	0.483	2582	0.437	895
Mhoon sil	24-28	2	532	7	219	1.69	108	0.407	2716	0.439	772
		LSD 0.05:	NS	NS	9	0.06	10	0.037	NS	NS	92
Jeanerette sil	14-18	1	270	4	91	1.66	76	0.452	3283	0.417	950
Jeanerette sil	14-18	2	227	4	38	1.50	78	0.406	3163	0.338	882
		LSD 0.05:	18	NS	12	0.02	NS	0.024	NS	0.025	NS
Jeanerette sil	24-28	1	404	2	154	1.73	64	0.520	2875	0.509	948
Jeanerette sil	24-28	2	397	2	104	1.54	83	0.513	2773	0.406	938
		LSD 0.05:	NS	NS	29	0.04	9	NS	NS	0.029	NS

1/ In the Mhoon silt loam, sampling periods 1 and 2 were in 1960 and in 1972-73, respectively.
In the Jeanerette silt loam, sampling periods 1 and 2 were in 1959 and in 1972-73, respectively.

2/ Extractant 1 = modified Bray 1 method and extractant 2 = modified Bray 2 method.

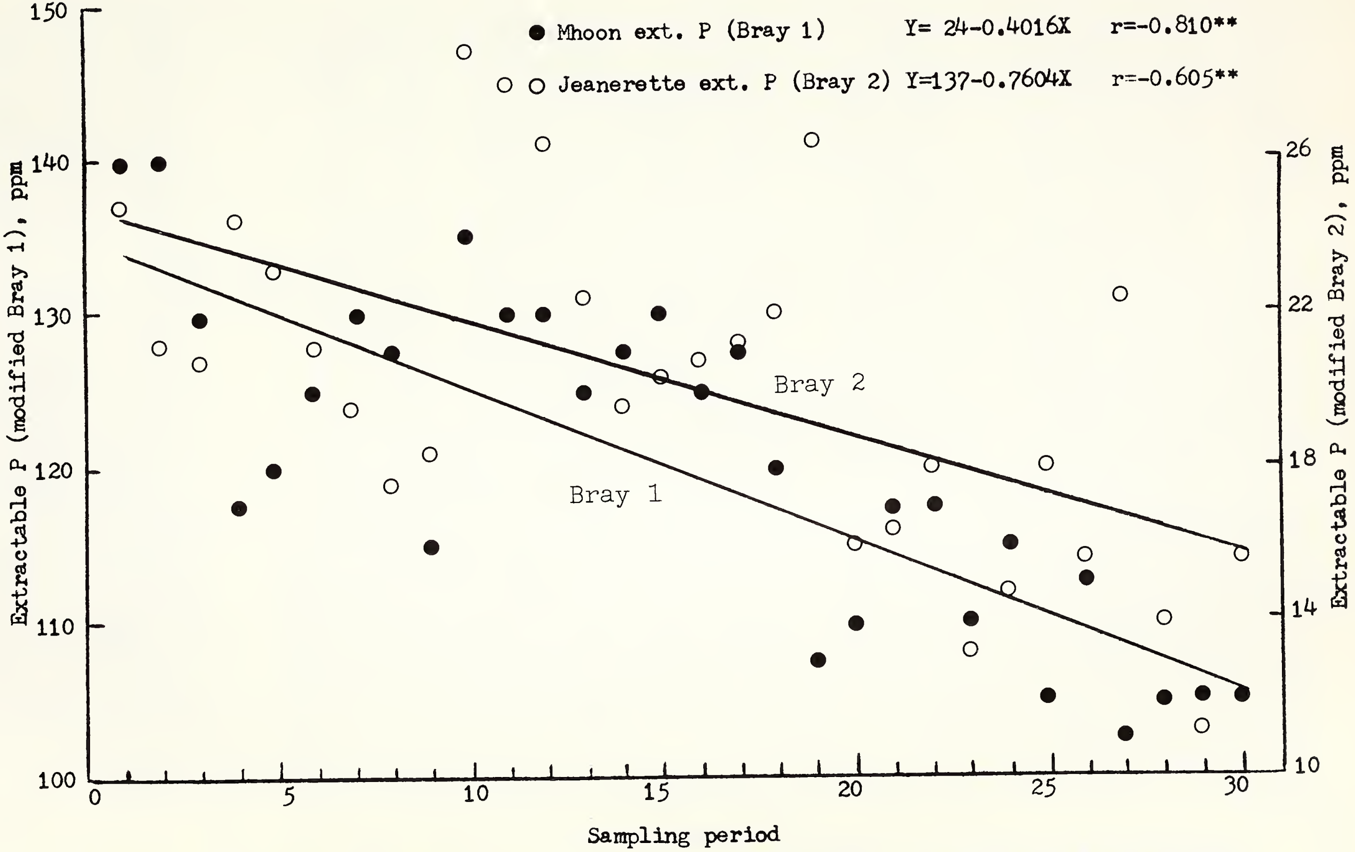

Figure 6. The relationship of sampling period to modified Bray 1 and Bray 2 P extractable from Mhoon and Jeanerette topsoil.

Total and Extractable K

Total K

Although there were some indications of small increases in total K contents of the topsoil during the period of sampling at each location, the relationships were not statistically significant.

The total K contents of the B and C horizons of both soils were statistically lower at the end of the sampling period (Table 7). In the Mhoon soil, the absolute decrease in total K noted in the B horizon was 0.34%, or 10,200 pounds of K per acre, and in the C horizon the absolute decrease was 0.11%, or 3,300 pounds per acre. The absolute decreases of total K in the B and C horizons of the Jeanerette soil were 0.16%, or 4,800 pounds per acre, and 0.19%, or 5,700 pounds per acre, respectively.

The K content of millable cane and trash in Louisiana is equivalent to about 3.5 pounds of K_2O per ton of cane (*17*). Considering K content and yield of cane, K equivalent to 1,004 pounds of K_2O per acre was removed from the Mhoon soil and K equivalent to 1,029 pounds of K_2O per acre was removed from the Jeanerette soil in harvested cane.

The losses in total K from the Mhoon soil were equivalent to 12,289 pounds of K_2O per acre from the B horizon and 3,976 pounds of K_2O per acre from the C horizon. Losses in total K from the Jeanerette soil were equivalent to 5,783 pounds of K_2O per acre from the B horizon and 6,867 pounds of K_2O per acre from the C horizon.

From these data it may be seen that the loss of K from the three Mhoon horizons was equivalent to 16,265 pounds of K_2O per acre during the 13-year period. Calculated loss from the three Jeanerette horizons was 12,650 pounds of K_2O per acre. Although the losses of K from the soils studied appear to be high, they represent decreases of only 9.1% in the Mhoon soil and 7.8% in the Jeanerette soil during the 13 years at each location.

The total K content of soils cropped to sugarcane in Louisiana is high but the portion available to the crop is low (*17, 28*). The primary concern at present with regard to K fertilization of sugarcane in Louisiana should be whether economic returns may be realized from K applied in fertilizers.

Extractable K

The amount of extractable K in the Mhoon topsoil did not change significantly. Extractable K in the Jeanerette topsoil decreased during the study (Table 5 and Figure 7).

In the Mhoon soil at the end of the study, extractable K was statistically lower in the B horizon but was statistically higher in the C horizon (Table 7). In the Jeanerette soil at the end of 13 years, extractable K had not changed significantly in the B horizon but had increased in the C horizon.

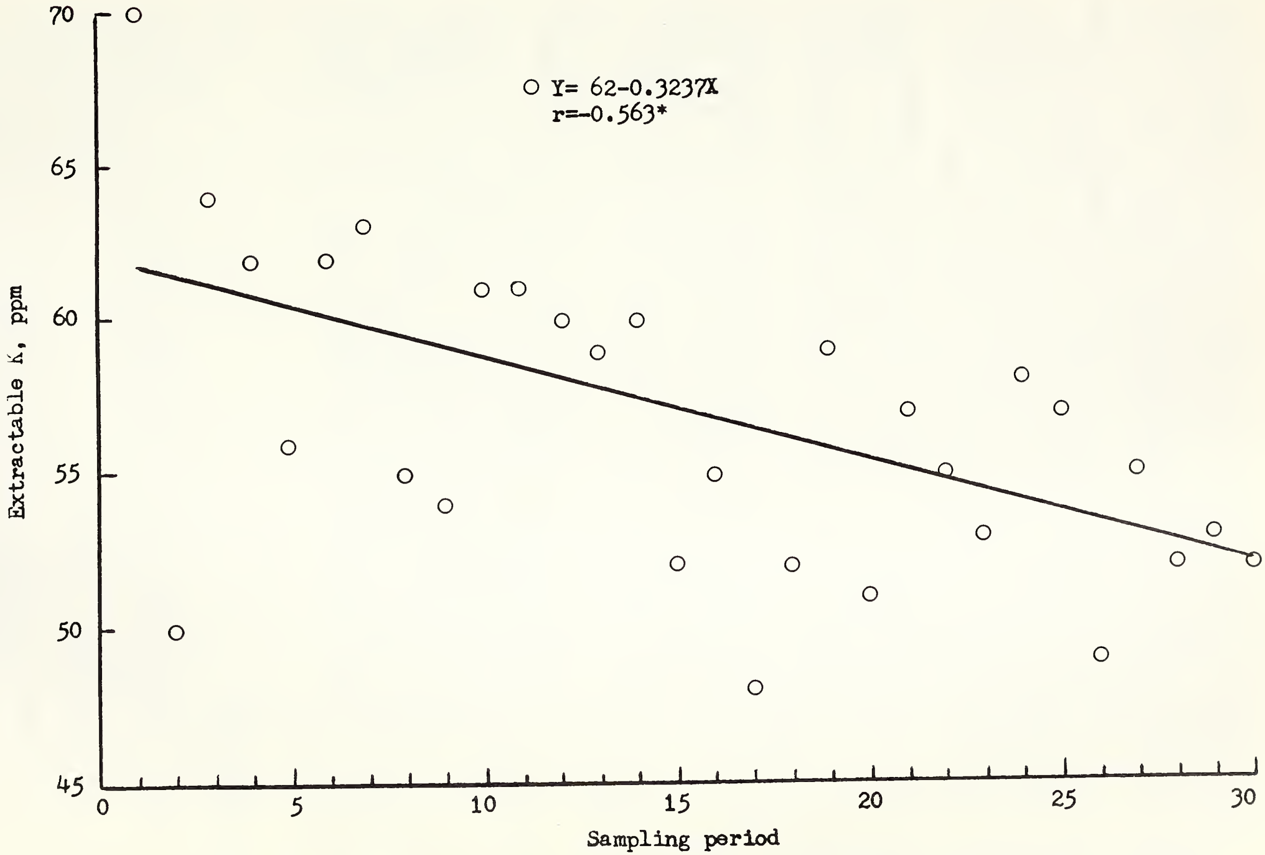

Figure 7. The relationship of sampling period to extractable K in Jeanerette topsoil.

Total and Extractable Ca

Total Ca

The amount of total Ca in the topsoil at each location generally decreased. The regression equations (Tables 4 and 5) indicated 0.039%, or 780 pounds per acre, loss from Mhoon topsoil and 0.024%, or 480 pounds per acre, loss from Jeanerette topsoil.

In the Mhoon soil, total Ca content increased significantly in the B horizon but decreased significantly in the C horizon (Table 7). Calculations indicate a net loss of 2,280 pounds of Ca per acre, or 6.6%, from the Mhoon horizons studied. The apparent reason for some of the increase in total Ca in the B horizon of the Mhoon soil may be more clearly shown under the discussion of total Mg in the Mhoon soil.

In the Jeanerette soil, total Ca in the B horizon decreased significantly but no significant change occurred in the C horizon (Table 7). The loss of Ca from the topsoil and B horizon was 1,860 pounds per acre, which is equivalent to a decrease of 4.7% in the three Jeanerette horizons.

An average of about 0.46 pound of Ca is contained in each ton of millable cane and accompanying trash in Louisiana (*14, 18, 29*). From cane yield and Ca content data, it was estimated that the amount of Ca removed by harvested cane was about 132 pounds per acre from the Mhoon soil and 135 pounds per acre from the Jeanerette soil.

The total loss of Ca from the three horizons of the Mhoon soil was equivalent to 3,192 pounds of CaO per acre, and the loss from the Jeanerette soil was equivalent to 2,604 pounds of CaO per acre.

It was determined that the loss of Ca from the Mhoon soil by means other than in millable cane and trash was equivalent to 3,007 pounds of CaO per acre during the 13-year period, or an average of 231 pounds of CaO per acre per year. The loss of Ca from the Jeanerette soil by means other than in millable cane and trash was equivalent to 2,415 pounds of CaO per acre, or 186 pounds of CaO per acre per year.

Extractable Ca

Results from analyses of the Mhoon topsoil samples did not show a significant relationship between the extractable Ca and the sampling period. However, extractable Ca in the Jeanerette topsoil decreased during the study (Table 5).

Extractable Ca in the B horizon of the Mhoon soil decreased significantly but an increase in the C horizon was not significant at the 5% level of probability. The small decreases of Ca extractable from the B and C horizons of the Jeanerette soil were not statistically significant (Table 7).

Total and Extractable Mg

Total Mg

A highly significant relationship was found between total Mg in the topsoil and sampling period at each location (Tables 4 and 5). From the regression equations, it was noted that the amount of total Mg in the Mhoon topsoil increased 0.033%, or 660 pounds per acre, and that total Mg content of the Jeanerette topsoil decreased 0.054%, or 1,080 pounds per acre.

The amount of total Mg decreased in the B horizon of the Mhoon soil but did not change significantly in the C horizon (Table 7). Calculations showed that there was a net loss of 2,940 pounds of total Mg per acre, or a decrease of 8.8%, in the three Mhoon horizons.

The increase in total Mg content of Mhoon topsoil probably was due to some admixture of soil from the B horizon with topsoil during fallow plowing and/or cultivation of the crop. This appears plausible when it is noted in Table 7 and in Table 14 (in the Appendix) that the total Mg was higher in the Mhoon B horizon than in the Mhoon topsoil. Additionally, in Tables 7 and 14, it can be seen that there was less total Ca in the Mhoon B horizon than in the Mhoon topsoil at the beginning and that the values were approximately equal at the end of the experiment, thus indicating a possibility of some mixing of Ca in the two horizons.

Total Mg in the B and C horizons of the Jeanerette soil decreased significantly (Table 7). The absolute decrease in Mg from the three Jeanerette horizons was 6,540 pounds per acre, which was equivalent to a relative decrease of 19%.

The average Mg content of millable cane and trash in Louisiana is about 0.51 pound per ton of millable cane (*14, 18, 29*); hence about 146 pounds of Mg were removed from the Mhoon soil and 150 pounds of Mg were removed from the Jeanerette soil in harvested cane.

The average decrease in Mg content of the three Mhoon horizons was equivalent to 4,875 pounds of MgO per acre. Data from the Jeanerette soil showed a decrease in total Mg equivalent to 10,843 pounds of MgO per acre.

The loss of Mg from the three Mhoon horizons by means other than in millable cane and trash was equivalent to 4,633 pounds of MgO per acre during the 13 years, or an average of 356 pounds per acre per year. Similar calculations indicated a loss of 10,594 pounds per acre from the three Jeanerette horizons, or an average loss of 815 pounds of MgO per acre per year.

Extractable Mg

The amount of extractable Mg increased in the Mhoon topsoil but decreased in the Jeanerette topsoil (Tables 4 and 5).

In Table 7, it may be seen that the amounts of extractable Mg in the B and C horizons of the Mhoon soil were significantly lower at the end of the study. The amounts of extractable Mg in the B and C horizons of the Jeanerette soil did not change significantly.

Soil pH

The topsoil pH in both soil types generally decreased. The correlation coefficient between pH of the Mhoon topsoil and sampling period was highly significant and the correlation coefficient between pH of the Jeanerette topsoil and sampling period was significant at the 5% level of probability (Tables 4 and 5).

At the end of the experiments, the soil pH values in the B and C horizons of the Mhoon soil were generally lower while those of the B and C horizons of the Jeanerette soil had not changed appreciably (Tables 12 and 13 in the Appendix).

Correlations

Tables 8 and 9 contain correlation coefficients among chemical properties of Mhoon topsoil and Jeanerette topsoil.

The organic C and total N were highly correlated in both soils. Organic C and "Soil" S were significantly correlated in the Mhoon soil and, in the Jeanerette soil, were correlated to a highly significant degree. The correlation coefficient between total N and "Soil" S in the Mhoon soil (0.306) was not statistically significant, but the correlation between total N and "Soil" S in the Jeanerette soil was highly significant.

It is interesting to note that correlations between organic C and total P were highly significant in both soils. This suggests that a relatively high portion of the soil P was contained in the soil organic matter.

It may be noted that soil pH was not significantly related to total Ca and Mg contents of either soil but was related to extractable Ca and Mg in the Jeanerette soil.

No significant relationship between "Soil" S and extractable S was found in the Mhoon soil, but the relationship was highly significant in the Jeanerette soil.

The relationships between total P and extractable P (Bray 1) in the Mhoon soil and between total P and extractable P (Bray 2) in the Jeanerette soil were highly significant. Total K and extractable K were not significantly related in either soil. Total Ca was significantly related to extractable Ca in the Jeanerette soil. Correlations between total Mg and extractable Mg were highly significant in both soils.

Other significant relationships among chemical properties were noted which may be characteristics of each soil. However, inconsistencies between comparable correlation values from the two soils precluded generalizations which could apply to both soils.

Table 8. Correlation coefficients (r)1/ among soil chemical properties of Mhoon topsoil.

	Total N	C/N ratio	"Soil" S	Ext. S	N/"Soil" S ratio	pH	Total P	Ext.P (No.1)	Ext.P (No.2)	Total K	Ext. K	Total Ca	Ext. Ca	Total Mg	Ext. Mg
Organic C	.814	.603	.446	.379	.318	.533	.736	.736	-.075	-.391	-.002	.437	-.293	-.575	-.555
Total N		.030	.306	.508	.588	.709	.743	.706	.047	-.225	-.067	.436	-.091	-.382	-.492
C/N ratio			.347	-.060	-.259	-.047	.245	.303	-.201	-.390	.083	.183	-.364	-.474	-.275
"Soil" S				.282	-.586	.303	.132	.151	.052	-.232	.265	-.197	.276	.043	.263
Ext. S					.185	.398	.363	.486	.036	.011	.257	-.197	-.253	-.240	-.332
N/"Soil" ratio						.360	.515	.453	.015	.011	-.273	.548	-.295	-.339	-.628
pH							.526	.334	.263	-.263	-.075	.338	.262	-.005	-.158
Total P								.672	.041	-.110	-.068	.499	-.320	-.489	-.610
Ext. P (modified Bray 1)									-.084	-.222	.013	.380	-.459	-.638	-.702
Ext. P (modified Bray 2)										.085	.351	-.037	.398	.328	.322
Total K											.323	-.215	.009	.547	.167
Ext. K												-.289	.183	.272	.342
Total Ca													-.070	-.310	-.385
Ext. Ca														.678	.808
Total Mg															.787

1/ Least significant r at 1% level = 0.463
Least significant r at 5% level = 0.361

Table 9. Correlation coefficients (r) 1/ among soil chemical properties of Jeanerette topsoil.

	Total N	C/N ratio	"Soil" S	Ext. S	N/"Soil" S ratio	pH	Total P	Ext.P (No.1)	Ext.P (No.2)	Total K	Ext. K	Total Ca	Ext. Ca	Total Mg	Ext. Mg
Organic C	.906	.404	.855	.692	-.351	-.065	.764	-.078	.511	.023	.417	.438	.369	.711	.700
Total N		-.021	.858	.827	-.234	.223	.856	.120	.588	-.137	.512	.456	.447	.736	.725
C/N ratio			.166	-.148	-.323	-.624	-.045	-.436	-.073	.346	-.122	.035	-.079	.098	.099
"Soil" S				.807	-.696	.113	.762	.011	.559	-.053	.557	.431	.468	.725	.737
Ext. S					-.370	.484	.803	.396	.692	-.326	.707	.252	.540	.717	.768
N/"Soil" ratio						.093	-.250	.145	-.246	-.097	-.343	-.189	-.255	-.331	-.373
pH							.387	.479	.284	-.515	.295	.269	.596	.356	.397
Total P								.169	.586	-.164	.539	.605	.553	.763	.765
Ext. P (modified Bray 1)									.295	-.188	.378	-.049	-.090	-.111	-.072
Ext. P (modified Bray 2)										-.126	.521	.181	.361	.558	.534
Total K											-.118	.130	-.280	-.268	-.308
Ext. K												.161	.304	.376	.484
Total Ca													.438	.474	.427
Ext. Ca														.795	.855
Total Mg															.932

1/ Least significant r at 1% level = 0.463
Least significant r at 5% level = 0.361

SUMMARY AND CONCLUSIONS

An investigation was made to determine the influence of cropping soils to sugarcane fertilized with N on macronutrient and organic C content of soils and soil pH. The study was conducted on a Mhoon silt loam during a 13-year period beginning in 1960 and on a Jeanerette silt loam during a 13-year period beginning in 1959. Topsoil samples were taken in early spring, at midseason and at harvest during 10 crop years. The soil was fallowed three years. Soil samples were taken from the B and C horizons at the beginning and at the end of the study.

During the study there was a general decrease in the organic C content of the topsoil. In the Mhoon topsoil, organic C content decreased 27% and in the Jeanerette topsoil the decrease was 23%. Since there was an increase in organic C content in each of the two lower Mhoon horizons, the weighted average of organic C in the three Mhoon horizons was 2.7% higher at the end than at the beginning of the study. The organic C contents of the B and C horizons in the Jeanerette soil were statistically lower at the end than at the beginning of the study. The average decrease in the organic C content of the three Jeanerette horizons was 20%. The organic C content of the Jeanerette soil was relatively high, and although it decreased during the study, it did not reach the low and relatively constant level normally expected in soils that are row cropped continuously.

General decreases in total N contents of topsoil at each location were observed. The decreases were 25% in the Mhoon topsoil and 23% in the Jeanerette topsoil. At the end of the experiment, the total N content of the B horizon in the Mhoon soil had not changed significantly, but an increase in total N had occurred in the C horizon. Although 554 more pounds of N were added in fertilizer than were removed in millable cane and trash and by burning, the average total N content of the three Mhoon horizons was 3.1% lower at the end of 13 years. The B and C horizons of the Jeanerette soil contained statistically lower amounts of total N at the end of the experiment. The loss of total N from the three Jeanerette horizons was 15%.

It was concluded that organic C and total N contents of the Jeanerette soil were depleted at a serious rate, even though fertilizer N was applied at recommended rates. When considering the three horizons as a unit, the changes in amounts of organic C and total N in the Mhoon soil were small, but losses from the topsoil were substantial.

The "Soil" S was defined as the combined organic, oxidizable inorganic and soluble sulphate S in soils. The "Soil" S content of the Mhoon topsoil decreased during the first few years, but an increase from the lowest level occurred during the latter part of the study. Since increases in the B and C horizons occurred, the average "Soil"

S in the three Mhoon horizons was 9.6% higher at the end of the study, due apparently to atmospheric S from industrial activity in the area.

The "Soil" S content of the Jeanerette topsoil decreased, and lower amounts were also found in the B and C horizons. The average "Soil" S in the Jeanerette horizons was 16% lower after 13 years.

The rate of depletion of S from the Jeanerette soil was high when compared with the amount in the soil. However, since the loss was about equal to the amount removed from the field in millable cane and trash, it was concluded that any gain in S from the atmosphere and other sources was approximately equal to losses by leaching and other means. An application of S at the rate of 10 pounds per acre to the Jeanerette soil during each of the 10 crop years would have approximately equalled the amount of S removed in millable cane and trash (103 pounds), but a higher rate probably would have been required to maintain a constant amount of S in the soil, due to efficiency of uptake, leaching and other loss factors.

The amount of total P decreased in Mhoon topsoil and Jeanerette topsoil. The loss from the topsoil was 15% in each soil type. Total P content decreased in the B horizon of each soil type. No statistically significant change occurred in total P content of the C horizon at either location. At the end of the investigation, the average losses of total P from the three horizons of the Mhoon and Jeanerette soils were 7.5 and 8.8%, respectively.

The total K contents of topsoil did not change statistically during the sampling period at either location. The amounts of total K in the B and C horizons were statistically lower in each soil type at the end of the study. The losses of total K from the three horizons of the Mhoon and the Jeanerette soils averaged 9.1 and 7.8%, respectively.

Losses in total Ca and Mg contents of both soils occurred. The decreases in total Ca were 6.6% in the Mhoon soil and 4.7% in the Jeanerette soil. The total Mg decreased 8.8% in the Mhoon soil and 19% in the Jeanerette soil.

The depletion rates of P, K, Ca and Mg in each soil type were substantially greater than could be predicted based on the removal of these elements in millable cane and trash.

The correlation between pH of Mhoon topsoil and sampling period, or sequential time of sampling from the beginning to the end of the study, (-0.556) was highly significant and the correlation between pH of Jeanerette topsoil and sampling period (-0.394) was significant at the 5% level of probability. The pH of the B and C horizons of the Mhoon soil decreased significantly, while the pH values from the B and C horizons of the Jeanerette soil showed no significant changes.

In the Mhoon topsoil, there was a significant negative relationship between extractable S and sampling period and a highly significant negative relationship between extractable P (modified Bray 1 method) and sampling period. Extractable Mg in the Mhoon topsoil was positively related to the sampling period. In the Jeanerette soil, the amounts of extractable S, P (modified Bray 2 method), K, Ca and Mg showed significant or highly significant negative relationships to the sampling period.

Significant positive correlations were obtained between organic C and total N in the topsoil at both locations, and between total N and "Soil" S in Jeanerette topsoil. The highly significant positive correlation between the organic C and total P in the topsoil at each location suggests that a high portion of soil P was contained in soil organic matter. The topsoil pH was not significantly related to the total Ca and Mg contents at either location but was positively related to extractable Ca and Mg in the Jeanerette soil.

APPENDIX

Table 10. Organic C and total N contents, C/N ratio, "Soil" S and extractable S contents, N/"Soil" S ratio and pH of samples from the Mhoon topsoil.

Sample no.	Organic C	Total N	C/N ratio	S "Soil"	 Ext.	N/ "Soil" S ratio	pH
	%	%		ppm	ppm		
1	.759	.086	8.8	89	19	9.7	6.2
2	.707	.086	8.2	80	16	10.8	6.3
3	.811	.084	9.7	84	17	10.0	6.0
4	.686	.076	9.0	90	16	8.4	5.9
5	.671	.077	8.7	80	15	9.6	5.8
6	.692	.081	8.5	83	20	9.8	6.3
7	.707	.088	8.0	86	17	10.2	6.3
8	.780	.081	9.6	79	15	10.3	6.3
9	.676	.077	8.8	71	15	10.8	6.0
10	.707	.075	9.4	79	16	9.5	5.6
11	.748	.073	10.2	90	17	8.1	5.6
12	.676	.070	9.7	79	15	8.9	5.6
13	.593	.068	8.7	79	15	8.6	5.5
14	.660	.070	9.4	79	15	8.9	5.7
15	.666	.070	9.5	77	16	9.1	5.5
16	.759	.082	9.3	91	20	9.0	5.8
17	.691	.080	8.6	79	16	10.1	5.7
18	.645	.072	9.0	80	17	9.0	5.8
19	.593	.072	8.2	73	15	9.9	5.8
20	.574	.067	8.6	64	13	10.5	5.6
21	.527	.068	7.8	74	17	9.2	5.7
22	.536	.069	7.7	73	18	9.5	5.6
23	.552	.066	8.4	64	16	10.3	5.5
24	.557	.067	8.3	76	14	8.8	5.5
25	.572	.066	8.7	80	15	8.3	5.8
26	.614	.065	9.4	90	17	7.2	6.0
27	.614	.065	9.4	86	12	7.6	5.9
28	.552	.067	8.2	84	17	8.0	5.9
29	.607	.072	8.4	93	14	7.7	5.6
30	.572	.065	8.8	84	13	7.7	5.4

Table 11. Organic C and total N contents, C/N ratio, "Soil" S and extractable S contents, N/"Soil" S ratio and pH of samples from the Jeanerette topsoil.

Sample no.	Organic C	Total N	C/N ratio	S		N/"Soil" S ratio	pH
				"Soil"	Ext.		
	%	%		ppm	ppm		
31	1.281	.101	12.7	125	24	8.1	7.0
32	1.287	.103	12.5	121	21	8.5	7.0
33	1.225	.100	12.3	118	22	8.5	7.0
34	1.174	.100	11.7	122	21	8.2	7.0
35	1.256	.101	12.4	122	21	8.3	6.9
36	1.266	.099	12.8	126	20	7.9	6.8
37	1.174	.096	12.2	124	19	7.7	7.0
38	1.194	.098	12.2	124	20	7.9	7.0
39	1.197	.097	12.3	121	19	8.0	7.0
40	1.204	.096	12.5	125	24	7.7	7.0
41	1.240	.105	11.8	124	21	8.5	7.0
42	1.307	.105	12.4	125	20	8.4	6.9
43	1.256	.092	13.7	129	20	7.1	6.7
44	1.276	.095	13.4	115	14	8.3	6.4
45	1.157	.089	13.0	124	13	7.2	6.6
46	1.143	.089	12.8	111	14	8.0	6.7
47	1.153	.090	12.8	106	12	8.5	6.7
48	1.276	.095	13.4	109	14	8.7	6.5
49	1.090	.089	12.2	103	16	8.6	7.0
50	1.204	.092	13.1	103	14	8.9	6.7
51	1.053	.091	11.6	103	15	8.8	6.8
52	1.132	.091	12.4	108	15	8.4	6.7
53	1.122	.091	12.3	113	13	8.1	6.6
54	1.204	.091	13.2	118	15	7.7	6.4
55	1.001	.080	12.5	99	13	8.1	7.0
56	.976	.079	12.4	89	10	8.9	6.9
57	.925	.078	11.9	95	14	8.2	6.7
58	.997	.080	12.5	93	12	8.6	6.9
59	.987	.080	12.3	92	10	8.7	7.0
60	.976	.079	12.4	85	12	9.3	6.7

Table 12. Organic C and total N contents, C/N ratio, "Soil" S and extractable S contents, N/"Soil" S ratio and pH of samples from the Mhoon B and C horizons.

Sample no.	Organic C	Total N	C/N ratio	S		N/ "Soil" S ratio	pH
				"Soil"	Ext.		
	%	%		ppm	ppm		
			Mhoon B horizon, 1960				
61	.379	.059	6.4	55	10	10.7	6.8
62	.379	.059	6.4	55	10	10.7	6.9
63	.379	.059	6.4	52	9	11.3	6.8
64	.426	.062	6.9	58	11	10.7	6.8
65	.402	.057	7.1	59	11	9.7	6.8
66	.473	.060	7.9	59	10	10.2	7.0
67	.391	.068	5.8	73	13	9.3	6.7
68	.520	.068	7.7	59	11	11.5	6.8
69	.543	.063	8.6	69	12	9.1	6.9
$\bar{X}$	.432	.062	7.0	60	11	10.4	
			Mhoon B horizon, 1972-73				
97	.508	.058	8.8	65	13	8.9	6.5
98	.567	.060	9.5	66	16	9.1	6.6
99	.567	.059	9.6	59	13	10.0	6.5
100	.590	.059	10.0	65	18	9.1	6.4
101	.402	.055	7.3	65	15	8.5	6.8
102	.496	.057	8.7	58	18	9.8	6.5
103	.470	.056	8.4	69	14	8.1	6.6
104	.520	.058	9.0	60	12	9.7	6.5
105	.426	.056	7.6	73	14	7.7	6.7
$\bar{X}$	.505	.058	8.8	64	15	9.0	
			Mhoon C horizon, 1960				
70	.314	.046	6.8	52	11	8.8	7.5
71	.257	.045	5.7	42	8	10.7	7.5
72	.285	.037	7.7	42	10	8.8	7.4
73	.257	.037	7.0	45	8	8.2	7.3
74	.328	.045	7.3	43	10	10.5	7.2
75	.314	.040	7.9	40	13	10.0	7.5
76	.370	.049	7.6	58	12	8.4	7.2
77	.314	.045	7.0	53	8	8.5	7.3
78	.342	.043	8.0	55	11	7.8	7.5
$\bar{X}$	.309	.043	7.2	48	10	9.1	
			Mhoon C horizon, 1972-73				
106	.483	.051	9.5	71	14	7.2	7.0
107	.483	.058	8.3	73	12	7.9	6.9
108	.483	.053	9.1	65	13	8.2	6.9
109	.342	.050	6.8	60	12	8.3	7.2
110	.342	.052	6.6	65	13	8.0	7.0
111	.426	.054	7.9	58	12	9.3	7.1
112	.370	.052	7.1	56	10	9.3	7.1
113	.342	.049	7.0	60	12	8.2	7.4
114	.398	.052	7.7	55	13	9.5	7.1
$\bar{X}$	.408	.052	7.8	63	12	8.4	

Table 13. Organic C and total N contents, C/N ratio, "Soil" S and extractable S contents, N/"Soil" S ratio and pH of samples from the Jeanerette B and C horizons.

Sample no.	Organic C	Total N	C/N ratio	S		N/ "Soil" S ratio	pH
				"Soil"	Ext.		
	%	%		ppm	ppm		
			Jeanerette B horizon, 1959				
79	.736	.062	11.9	71	11	8.7	7.5
80	.877	.070	12.5	77	12	9.1	7.6
81	.877	.065	13.5	77	11	8.4	7.6
82	.905	.074	12.2	83	11	8.9	7.3
83	.919	.076	12.1	81	11	9.4	7.3
84	.793	.067	11.8	75	12	8.9	7.6
85	.877	.071	12.4	83	12	8.6	7.4
86	.863	.068	12.7	75	13	9.1	7.4
87	.764	.068	11.2	80	13	8.5	7.6
$\bar{X}$	.846	.069	12.3	78	12	8.8	
			Jeanerette B horizon, 1972-73				
115	.342	.061	5.6	75	15	8.1	7.4
116	.342	.060	5.7	68	13	8.8	7.5
117	.426	.061	7.0	71	13	8.6	7.4
118	.933	.060	15.6	75	14	8.0	7.5
119	.567	.068	9.8	75	14	9.1	7.4
120	.624	.068	9.2	75	15	9.1	7.3
121	.962	.068	14.2	74	13	9.2	7.3
122	.962	.062	15.5	62	14	10.0	7.5
123	.426	.061	7.0	66	14	9.2	7.5
$\bar{X}$	.620	.063	10.0	71	14	8.9	
			Jeanerette C horizon, 1959				
88	.454	.050	9.1	61	15	8.2	7.6
89	.483	.062	7.8	71	15	8.7	7.7
90	.511	.053	9.6	59	16	9.0	7.8
91	.553	.057	9.7	61	13	9.3	7.8
92	.483	.065	7.4	65	12	10.0	7.6
93	.483	.054	8.9	65	14	8.3	7.8
94	.511	.064	8.0	69	15	9.3	7.5
95	.539	.056	9.6	65	14	8.6	7.6
96	.483	.057	8.5	61	15	9.3	7.6
$\bar{X}$	.500	.058	8.7	64	14	9.0	
			Jeanerette C horizon, 1972-73				
124	.454	.046	9.9	61	11	7.5	7.7
125	.454	.047	9.7	58	9	8.1	7.7
126	.454	.049	9.3	55	11	8.9	7.4
127	.539	.051	10.6	58	11	8.8	7.7
128	.497	.053	9.4	61	10	8.7	7.6
129	.454	.050	9.1	58	9	8.6	7.6
130	.511	.051	10.0	59	9	8.6	7.6
131	.525	.054	9.7	62	10	8.7	7.6
132	.469	.053	8.9	58	10	9.1	7.6
$\bar{X}$	.484	.050	9.6	59	10	8.6	

Table 14. Total and extractable P, K, Ca and Mg contents of topsoil samples from Mhoon silt loam.

Sample	P			K		Ca		Mg	
no.	Total	Ext.1	Ext.2	Total	Ext.	Total	Ext.	Total	Ext.
	ppm	ppm	ppm	%	ppm	%	ppm	%	ppm
1	510	26	204	1.85	90	.420	1520	.314	312
2	491	26	205	1.80	64	.475	1499	.299	300
3	531	22	198	1.83	65	.435	1357	.297	274
4	498	17	199	1.83	60	.415	1469	.294	303
5	487	18	204	1.78	58	.410	1499	.293	321
6	490	20	201	1.75	67	.415	1561	.292	315
7	483	22	202	1.79	60	.445	1663	.310	329
8	473	21	197	1.76	50	.440	1479	.295	272
9	508	16	195	1.76	59	.470	1479	.290	293
10	480	24	205	1.80	85	.410	1448	.286	305
11	473	22	204	1.78	79	.435	1469	.287	303
12	475	22	189	1.79	66	.440	1448	.292	309
13	471	20	188	1.80	57	.430	1397	.295	296
14	462	21	188	1.80	61	.420	1438	.289	299
15	468	22	187	1.81	64	.415	1438	.292	307
16	461	20	190	1.79	74	.405	1367	.285	305
17	454	21	195	1.75	62	.415	1459	.293	309
18	458	18	187	1.79	65	.420	1397	.285	274
19	450	13	194	1.85	74	.415	1530	.317	325
20	457	14	201	1.85	68	.425	1469	.311	315
21	456	17	198	1.81	68	.370	1438	.309	309
22	455	17	205	1.85	69	.405	1510	.314	343
23	442	14	202	1.85	62	.430	1448	.317	314
24	446	16	202	1.84	65	.425	1469	.317	326
25	450	12	205	1.83	82	.415	1601	.329	390
26	443	15	208	1.78	70	.380	1510	.321	356
27	442	11	202	1.76	72	.435	1652	.325	406
28	440	12	197	1.85	71	.390	1612	.337	389
29	442	12	193	1.84	69	.400	1652	.342	395
30	433	12	201	1.77	66	.400	1571	.297	371

Table 15. Total and extractable P, K, Ca and Mg contents of topsoil samples from Jeanerette silt loam.

Sample no.	P			K		Ca		Mg	
	Total	Ext.1	Ext.2	Total	Ext.	Total	Ext.	Total	Ext.
	ppm	ppm	ppm	%	ppm	%	ppm	%	ppm
31	367	25	137	1.65	70	.515	2483	.308	560
32	376	23	128	1.65	50	.510	2463	.305	525
33	370	24	127	1.68	64	.510	2607	.303	531
34	360	20	136	1.66	62	.510	2596	.288	544
35	354	18	133	1.68	56	.505	2535	.290	507
36	372	18	128	1.65	62	.520	2484	.299	512
37	369	19	124	1.65	63	.520	2524	.285	517
38	360	16	119	1.66	55	.535	2535	.302	518
39	351	17	121	1.65	54	.515	2503	.301	520
40	352	27	147	1.65	61	.510	2422	.298	506
41	348	24	145	1.65	61	.495	2412	.297	489
42	374	20	141	1.66	60	.540	2432	.299	495
43	350	18	131	1.68	59	.490	2371	.287	497
44	352	14	124	1.70	60	.520	2278	.288	487
45	334	15	126	1.69	52	.520	2391	.285	472
46	338	12	127	1.66	55	.500	2268	.288	478
47	349	15	128	1.68	48	.515	2484	.292	480
48	335	13	130	1.69	52	.505	2340	.287	476
49	352	24	141	1.68	59	.510	2114	.254	395
50	337	21	115	1.66	51	.510	2176	.256	442
51	340	21	116	1.69	57	.500	2063	.255	386
52	336	24	120	1.65	55	.505	2114	.259	413
53	328	20	108	1.68	53	.500	2042	.258	394
54	329	20	112	1.70	58	.495	2052	.253	402
55	319	22	120	1.69	57	.510	2492	.263	445
56	334	23	114	1.69	49	.525	2258	.266	411
57	321	22	131	1.66	55	.480	2196	.258	410
58	318	16	110	1.63	52	.485	2391	.269	443
59	318	18	103	1.66	53	.510	2422	.265	419
60	314	19	114	1.65	52	.470	2155	.259	413

Table 16. Total and extractable P, K, Ca and Mg contents of samples from Mhoon B and C horizons.

Sample	P			K		Ca		Mg	
no.	Total	Ext.1	Ext.2	Total	Ext.	Total	Ext.	Total	Ext.
	ppm	ppm	ppm	%	ppm	%	ppm	%	ppm
				Mhoon B horizon, 1960					
61	521	8	235	2.00	108	0.375	2881	0.483	895
62	520	9	246	1.96	87	0.385	2675	0.475	768
63	521	8	237	1.95	111	0.380	2593	0.471	746
64	522	10	235	1.99	98	0.375	2758	0.502	811
65	532	9	239	1.99	102	0.360	2675	0.484	837
66	526	8	235	2.00	104	0.385	2634	0.484	737
67	504	11	206	2.00	114	0.345	2922	0.542	924
68	484	10	226	1.90	80	0.395	2326	0.431	780
69	516	9	220	1.95	115	0.390	2902	0.514	814
$\bar{X}$	516	9	231	1.97	102	0.377	2707	0.487	842
				Mhoon B horizon, 1972-73					
97	461	9	198	1.69	91	0.415	2922	0.375	555
98	464	11	200	1.65	87	0.405	2099	0.365	528
99	444	12	213	1.46	82	0.415	2017	0.353	495
100	466	12	189	1.60	78	0.420	2428	0.361	513
101	468	10	193	1.65	95	0.405	2346	0.408	627
102	447	12	195	1.63	75	0.405	2428	0.349	519
103	469	9	202	1.65	97	0.395	2346	0.341	630
104	468	15	202	1.66	78	0.400	2058	0.352	516
105	470	11	193	1.70	93	0.365	2593	0.403	637
$\bar{X}$	462	11	198	1.63	86	0.403	2360	0.367	558
				Mhoon C horizon, 1960					
70	526	9	271	1.86	80	0.460	2614	0.441	979
71	518	11	293	1.82	56	0.480	2079	0.375	855
72	480	9	295	1.69	78	0.515	2428	0.404	830
73	537	7	282	1.80	67	0.490	2346	0.403	827
74	527	7	267	1.86	86	0.465	2614	0.453	956
75	543	9	280	1.79	90	0.580	3581	0.511	947
76	531	6	259	1.85	102	0.410	2758	0.504	934
77	520	5	275	1.79	84	0.455	2367	0.433	864
78	539	7	296	1.76	73	0.495	2449	0.412	865
$\bar{X}$	525	8	280	1.80	80	0.483	2582	0.437	895
				Mhoon C horizon, 1972-73					
106	531	7	228	1.65	113	0.400	2634	0.413	748
107	537	7	217	1.66	101	0.410	2758	0.432	735
108	536	7	216	1.67	117	0.400	2717	0.438	739
109	532	7	217	1.67	99	0.415	2634	0.446	810
110	496	7	217	1.67	106	0.410	2593	0.435	755
111	510	6	217	1.70	113	0.400	2675	0.456	818
112	516	6	231	1.69	107	0.395	2675	0.444	802
113	549	6	220	1.74	101	0.410	2840	0.450	772
114	584	7	208	1.73	102	0.420	2922	0.435	768
$\bar{X}$	532	7	219	1.69	108	0.407	2716	0.439	772

Table 17. Total and extractable P, K, Ca and Mg contents of samples from the Jeanerette B and C horizons.

Sample no.	P			K		Ca		Mg	
	Total	Ext.1	Ext.2	Total	Ext.	Total	Ext.	Total	Ext.
	ppm	ppm	ppm	%	ppm	%	ppm	%	ppm
Jeanerette B horizon, 1959									
79	272	3	93	1.65	75	0.440	3063	0.420	1010
80	271	4	95	1.65	71	0.415	3105	0.406	930
81	263	2	87	1.66	93	0.430	3147	0.420	973
82	265	4	79	1.65	67	0.430	2893	0.422	938
83	241	5	75	1.65	65	0.435	2893	0.376	876
84	269	5	95	1.66	82	0.475	3823	0.436	1016
85	266	4	90	1.66	76	0.450	3189	0.403	887
86	296	4	88	1.67	72	0.500	3358	0.415	928
87	288	5	113	1.67	79	0.490	4076	0.454	991
$\overline{X}$	270	4	91	1.66	76	0.452	3283	0.417	950
Jeanerette B horizon, 1972-73									
115	236	3	48	1.51	97	.410	3337	0.356	954
116	219	3	53	1.50	91	.400	3421	0.379	968
117	250	3	45	1.46	91	.400	3168	0.363	961
118	227	3	33	1.48	78	.400	3168	0.348	913
119	220	4	37	1.53	63	.410	2915	0.310	770
120	225	4	28	1.50	71	.420	3126	0.310	842
121	237	4	33	1.51	59	.415	3210	0.292	751
122	215	4	33	1.48	78	.400	3084	0.342	892
123	211	4	28	1.50	76	.395	3041	0.340	891
$\overline{X}$	227	4	38	1.50	78	.406	3163	0.338	882
Jeanerette C horizon, 1959									
88	404	2	118	1.71	58	0.570	2810	0.574	944
89	384	2	162	1.72	59	0.520	2644	0.497	950
90	409	2	134	1.75	72	0.540	2603	0.548	808
91	412	3	144	1.70	58	0.480	2851	0.536	880
92	407	2	179	1.71	58	0.510	2727	0.482	932
93	424	2	180	1.70	68	0.560	3058	0.523	1064
94	386	2	157	1.75	67	0.450	3099	0.445	928
95	399	3	155	1.76	71	0.520	3430	0.464	1001
96	414	3	157	1.75	64	0.530	2658	0.511	1027
$\overline{X}$	404	2	154	1.73	64	0.520	2875	0.509	948
Jeanerette C horizon, 1972-73									
124	394	1	142	1.53	87	.520	2810	0.421	950
125	364	1	120	1.54	89	.595	2727	0.440	992
126	401	1	124	1.56	89	.500	2190	0.427	739
127	407	2	90	1.53	85	.480	2810	0.398	954
128	389	2	92	1.53	82	.470	2851	0.387	946
129	411	2	89	1.51	70	.510	2934	0.393	1008
130	403	3	84	1.64	79	.490	2851	0.401	917
131	407	3	96	1.48	76	.530	2934	0.382	926
132	396	3	101	1.50	89	.520	2851	0.401	1012
$\overline{X}$	397	2	104	1.54	83	.513	2773	0.406	938

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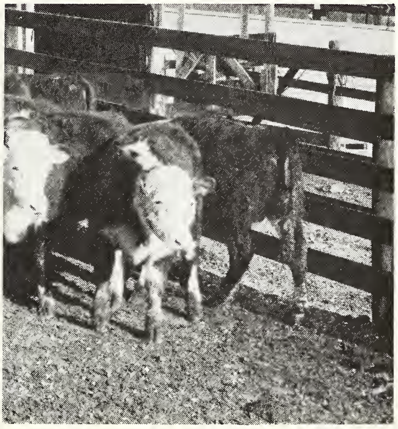

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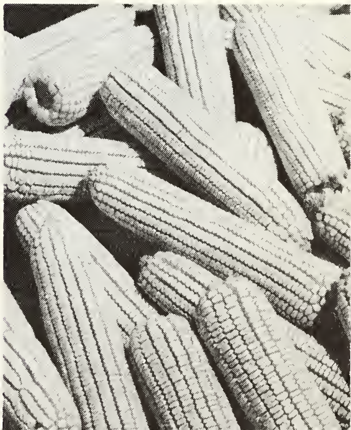

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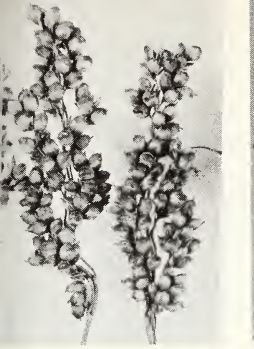

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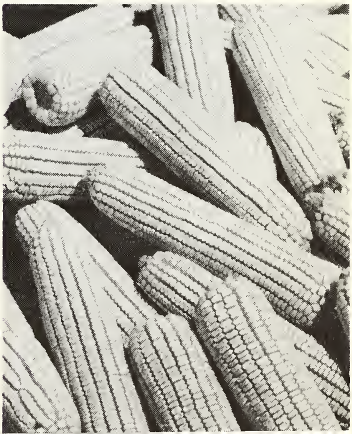

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Comparisons of Corn and a Bird-Resistant Grain Sorghum in Beef Finishing Rations

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F. G. HEMBRY[1]

INTRODUCTION

Grain sorghums have been used in increasing amounts in recent years as a substitute for corn in beef cattle rations. These grains generally tolerate drought conditions, poor soil fertility, and poor soil structures much better than corn and can be grown in areas unsuitable for corn production.

In some areas, losses of grain sorghum to birds have been excessive. Grain sorghum varieties that have a high tannic acid content and are unpalatable to birds have been developed. These varieties are known as bird-resistant (BR) grain sorghums. Conflicting reports appear in the literature concerning the feeding value of these bird-resistant hybrids.

Fox *et al.* (1970) found that calves full fed a whole grain corn ration gained significantly faster and more efficiently than calves full fed a whole grain bird-resistant grain sorghum ration. When the grains were finely ground, the calves fed corn did not gain significantly faster or more efficiently than the calves fed bird-resistant sorghum.

Two trials were conducted at the Dean Lee Agricultural Center, Alexandria, to compare bird-resistant grain sorghum with corn as the energy source in complete, ground rations for finishing beef cattle. The effect of the level of grain sorghum in the ration on gains, consumption, conversion, and carcass characteristics was studied in the first trial. The second trial examined the effect of increasing the level of digestible protein in the sorghum ration on the same characteristics.

PROCEDURE

Six rations were used in the two trials. They are listed in Table 1.

In Trial 1, Rations 1 through 4 were fed to 48 calves for 116 days to determine the effect of substituting increasing amounts of bird-resistant grain sorghum for corn. Each ration was fed to two pens of six calves. Thus, there were 48 calves allotted to two replications of four treatments. Treatment numbers corresponded to ration numbers.

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[1] Assistant Professor, Superintendent, and Assistant Professor, Dean Lee Agricultural Center, Alexandria, Louisiana, and Associate Professor, Department of Animal Science, LSU, Baton Rouge, Louisiana, respectively.

Table 1.—Composition of rations

Ingredient	Ration 1 100% corn	Ration 2 50% corn, 50% sorghum	Ration 3 25% corn, 75% sorghum	Ration 4 100% sorghum	Ration 5 50% corn, 50% sorghum, added protein	Ration 6 100% sorghum, added protein
	Pounds					
Corn	1,644	824	412	—	767	—
Sorghum	—	824	1,237	1,650	767	1,424
Cottonseed hulls	200	200	200	200	200	200
Cottonseed meal	—	—	—	—	110	220
Urea	26	22	21	20	26	26
Oystershell flour	20	20	20	20	20	20
Salt	10	10	10	10	10	10
Vitamins[1]	0.5	0.5	0.5	0.5	0.5	0.5
Antibiotics[2]	1.0	1.0	1.0	1.0	1.0	1.0
Molasses	100	100	100	100	100	100
Total	2,001.5	2,001.5	2,001.5	2,001.5	2,001.5	2,001.5

[1] A,D,E Premix—1,500,000 USP Units Vit. A, 500,000 IC Units Vit.D, 300 IC Units Vit. E.

[2] TM-10 (10 g. Terramycin/lb.).

Ration 1, the control ration, contained 100 percent corn as the energy source. Ration 2 contained 50 percent corn and 50 percent grain sorghum. Ration 3 contained 25 percent corn and 75 percent grain sorghum, and Ration 4 was composed of 100 percent grain sorghum. These four rations were balanced according to estimated crude protein levels as shown in Table 2.

In Trial 2, Rations 1, 4, 5, and 6 were fed for 140 days to examine the effect of increasing the level of digestible protein in the sorghum rations. Ninety-six calves were allotted to these four treatments, with three replications of eight calves per pen. Rations 5 and 6 were essentially the same as Rations 2 and 4 from Trial 1, except that cottonseed meal was substituted for some of the grain in an attempt to make the digestible protein level of the rations equal to the 100 percent corn ration.

The grain sorghum and corn fed in this study were produced at the Dean Lee Agricultural Center. All grain for the six rations was ground through a ½-inch screen and the rations were mixed in an upright mixer. The sorghum used was Funk's BR-79 and the corn was a mixture of several varieties.

The rations were full fed in bunk-type feeders in a concrete confinement facility.

Cattle were purchased at approximately 550 pounds and were allowed a 15-day adjustment period in the feedlot before going on test. All calves received routine worming and vaccinations and were implanted with 24 milligrams of diethystilbesterol about 10 days prior to going on test. Individual gains and group consumption and conversion data were obtained. Carcass weights and grades were obtained at slaughter.

Data were analyzed by completely random analysis of variance. In Trial 1, the following orthogonal comparisons were made: (1) Ration 1 vs. Rations 2, 3, and 4; (2) Ration 3 vs. Rations 2 and 4, and (3) Ration 2 vs. Ration 4. A linear regression was also computed on the response to the level of sorghum in the rations.

In Trial 2, the following orthogonal comparisons were made: (1) Rations 1 and 4 vs. Rations 5 and 6; (2) Ration 1 vs. Ration 4, and (3) Ration 5 vs. Ration 6.

RESULTS AND DISCUSSION

Trial 1. The data obtained when 48 calves were fed Rations 1 through 4 (Treatments 1 through 4) for 116 days are shown in Table 3. These four treatments had two replications of six calves per pen.

Average initital weights of calves in Treatments 1 through 4 were 512, 523, 511, and 497 pounds, respectively. Average final weights for the respective treatments were 814, 826, 791, and 729 pounds.

The level of grain sorghum in the ration had a highly significant effect on average daily gains. While there were no differences between

Table 2.—Ration analysis

Item	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6
	100% corn	50% corn, 50% sorghum	25% corn, 75% sorghum	100% sorghum	50% corn, 50% sorghum, added protein	100% sorghum, added protein
Crude protein %	11.5	11.5	11.5	12.0	13.9	16.2
Digestible protein, %	8.7	6.8	5.9	5.1	8.9	9.2
Total digestible nutrients, %	74	63	58	56	60	46

Table 3.—Performance of calves in Trial 1

Item	Ration 1 100% corn	Ration 2 50% corn, 50% sorghum	Ration 3 25% corn, 75% sorghum	Ration 4 100% sorghum
Avg. initial wt., lb.	512	523	511	497
Avg. final wt., lb.	814	826	791	729
Avg. daily gain, lb.**	2.70	2.71	2.50	2.08
Feed/100 lb. gain, lb.*	707	775	817	959
Avg. daily intake, lb.	19.1	21.0	20.4	19.9
Avg. carcass wt., lb.**	484	482	473	415
Avg. carcass grade[1]	10.8	10.5	10.0	9.8

*($P < .05$). **($P < .01$).

[1] Average good = 10.0.

Ration 1 and the average of the other three rations, Ration 2 calves gained faster ($P < .01$) than Ration 4 calves. A significant ($P < .05$) linear gain response resulted from feeding Rations 2, 3, and 4. As the level of sorghum in the rations was increased from 50 percent to 75 percent to 100 percent, average daily gains decreased from 2.71 pounds to 2.50 pounds to 2.08 pounds.

Differences in the conversion of feed to gains were highly significant. Treatment 1 calves were more efficient ($P < .01$) than the average of the other three treatments and Ration 2 calves were more efficient ($P < .01$) than Ration 4 calves. The response to the levels of sorghum in Rations 2, 3, and 4 was again linear and significant at the .05 level. Feed required per 100 pounds of gain for Rations 1 through 4, respectively, was 707, 775, 817, and 959 pounds. Average daily intake ranged from 19.1 to 21.0 pounds per day, with no significant ($P > .05$) differences between rations.

Average carcass weights were reflections of average daily gains, and there were highly significant differences among treatments. These differences were also influenced by differences in on-test weights. Ration 1 calves had significantly heavier carcasses than the average of the other three rations (484 vs. 482, 473, and 415 pounds). Ration 2 calves were heavier ($P < .01$) than Ration 4 calves, and the response over Rations 2, 3, and 4 was linear and significant at the .05 level. Carcass grades ranged from 9.8 to 10.8 with no significant ($P > .05$) differences between treatments.

Data from Trial 1 indicated that cattle would consume bird-resistant grain sorghum as readily as they would corn, but that grain sorghum was not converted to gains as efficiently as was corn. It was felt that this decreased efficiency might be due to poor protein digestibility of the grain sorghum. Digestion trials conducted after the completion of Trial 1 indicated the sorghum used in this study had a much lower digestible protein level than corn (3.0 vs. 6.8 percent). Therefore, another study was conducted to determine the effects of raising the digestible protein level of the grain sorghum rations. The calculated digestible protein levels are shown in Table 2.

Trial 2. In this trial, Rations 1, 4, 5, and 6 were fed to 96 calves for 140 days. Rations 1 and 4 were the same as in Trial 1 and were the 100 percent corn and 100 percent sorghum rations, respectively. Rations 5 and 6 were the same as 2 and 4, except that the level of digestible protein was increased. Eight calves were allotted to each of three replications of the four ration treatments. Results of Trial 2 are listed in Table 4.

Table 4.—Performance of calves in Trial 2

	Ration 1	Ration 4	Ration 5	Ration 6
Item	100% corn	100% sorghum	50% corn, 50% sorghum, added protein	100% sorghum, added protein
Avg. initial wt., lb.	564	561	574	565
Avg. final wt., lb.	892	865	899	838
Avg. daily gain, lb.*	2.34	2.17	2.32	1.95
Feed/100 lb. gain, lb.**	761	1,134	940	1,103
Avg. daily intake, lb.**	17.8	24.6	21.8	21.6
Avg. carcass wt., lb.*	548	516	545	505
Avg. carcass grade[1]	10.4	10.1	10.1	10.0

*($P < .05$). **($P < .01$).

[1] Average good = 10.0.

Average initial weights for calves receiving Rations 1, 4, 5, and 6 were 564, 561, 574, and 565 pounds, respectively. Respective final weights were 892, 865, 899, and 838 pounds.

Average total gains for the four treatments were 328, 303, 324, and 273 pounds, respectively. The average daily gains were 2.34, 2.17, 2.32, and 1.95 pounds, respectively. Differences in gains were significant at the .05 level.

Comparisons between the two original rations (1 and 4) and the two rations with increased protein (5 and 6) were not significant ($P > .05$). Calves fed the 50-50 ration with an increased protein level gained faster ($P<.05$) than calves fed the 100 percent sorghum level with added protein (Rations 5 vs. 6). In this trial, there was no significant difference ($P > .05$) in gains between the 100 percent corn ration (Ration 1) and the original 100 percent sorghum ration (Ration 4).

There was a highly significant difference among rations in feed conversion. Pounds of feed required per 100 pounds of gain for Rations 1, 4, 5, and 6 were 761, 1,134, 940, and 1,103 pounds, respectively. Again there were no differences ($P > .05$) between the original rations and the rations with increased protein levels (Rations 1 and 4 vs. 5 and 6). Ration 5 calves required significantly less ($P < .01$) feed than Ration 6 calves and Ration 1 calves required less ($P < .01$) feed per 100 pounds of gain than Ration 4 calves.

Differences in daily consumption were highly significant. Calves fed Ration 1 consumed less ($P < .01$) feed daily than calves fed Ration 4. There were no differences in consumption between the averages of Rations 1 and 4 and Rations 5 and 6. Calves fed Ration 5 did not consume significantly more feed than calves fed Ration 6. Daily consumption of the four rations was 17.8, 24.6, 21.8, and 21.6 pounds, respectively.

Average carcass weights were significantly different between treatments. No differences were detected when Rations 1 and 4 were compared with Rations 5 and 6. A highly significant difference was found between Ration 5 and Ration 6 and also between Ration 1 and Ration 4. These differences were influenced to some extent by differences in on-test weights as well as gains on test. The average carcass weights for Rations 1, 4, 5, and 6 were 548, 516, 545, and 505 pounds, respectively.

There were no significant differences in carcass grades, which ranged from 10.0 to 10.4.

SUMMARY

The data from Trial 1 indicate that as the level of bird-resistant grain sorghum in the ration was increased to over 50 percent, performance was reduced. Although calves fed the 50 percent sorghum ration (Ration 2) in Trial 1 gained as well as calves fed the 100 percent corn ration (Ration 1), their consumption was higher and their efficiency of conversion was lower. Ration 2 calves required 9 percent more feed per pound of gain than Ration 1 calves, and Ration 4 calves required 36 percent more feed than Ration 1 calves. This decrease in efficiency is in agreement with data reported by McGinty and Riggs (1968) and Hinders and Eng (1971). McGinty, Riggs and Kunkel (1969) also reported that the *in vitro* digestibility of bird-resistant grain sorghum was lower than that of bird-susceptible sorghum.

Trial 2 data indicate that the level of digestible protein in the sorghum rations was not the limiting factor. Although calves fed Rations 4 and 5 gained as rapidly as Ration 1 calves, they required 49 and 24 percent more feed per 100 pounds of gain, respectively. This decrease in efficiency was again in agreement with reported data.

It was found in this study that cattle would readily consume bird-resistant grain sorghum rations, but would not perform as well on these rations as they would when fed corn rations.

Speculation that the lowered performance was due to a lower digestible protein level in the bird-resistant grain sorghum proved to be unfounded. Raising the digestible protein level in the rations did not improve performance. Actually, performance seemed to be lowered by increasing the digestible protein level of the ration. Data from Maxson *et al.* (1973) showed that the total digestible nutrient (TDN) value of bird-resistant grain sorghum was lower than that of corn or regular grain sorghum. This explains the lower feeding value of the bird-resistant grain sorghum. It also explains why the sorghum rations with increased levels of digestible protein were lower in feeding value. Grain in these rations was replaced with cottonseed meal to increase the protein level. This lowered the TDN levels of the rations even further.

The TDN level of the various grain sorghums had not been established when this project was initiated. Since this project has been completed, these values have been defined. The TDN levels of the rations in this study have been computed and are shown in Table 2. These values explain the differences in performance of calves fed these rations.

In summary, these data indicate that up to 50 percent of the corn in a finishing ration for cattle can be replaced with bird-resistant grain sorghum without significantly affecting rate of gain. However, efficiency in converting feed to gains will be reduced by the inclusion of the sorghum grain.

Whether or not the use of this sorghum grain would be economically feasible would depend upon the relative costs of corn and bird-resistant grain sorghum. Because only limited amounts of bird-resistant grain sorghum are available on the market, the cost of this grain would probably be the cost of on-the-farm production.

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